

Lamprey River

Protected Instream Flow Study



Lamprey River

Protected Instream Flow Study

- **Introduction**
- **Acceptance of meeting minutes**
- **Presentation of draft Lamprey PISFs**
 - **Natural flow paradigm concept**
 - **Flow dependent protected entities**
 - **Floodplain entities and transect findings**
 - **Aquatic entities and MesoHABSIM findings**
 - **Water supply**
 - **Assessment of PISFs**
 - **Final recommendations**

PISF Generalized Process

PISF Study

- Define protection goals
- Assess river conditions
- Define conditions to meet goals
- Establish numerical flow standards

WMP

- Evaluate problem reaches
- Evaluate management options
- Integrate options into a plan
- (Implement plans)

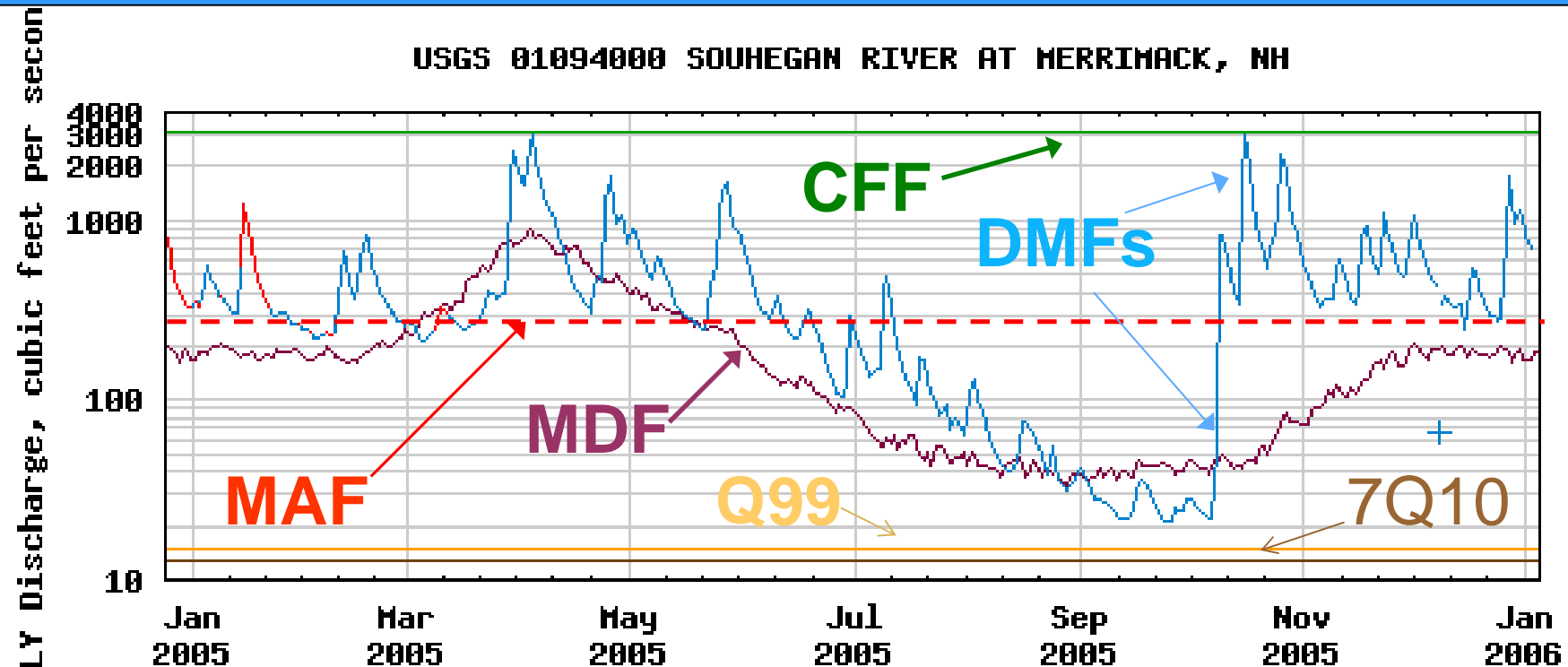
Some Protected Entities (Goals)

-
- The diagram illustrates the relationship between human uses and biological integrity. Two central concepts, 'Human uses' and 'Biological Integrity', are highlighted in dark blue ovals. Arrows point from 'Human uses' to a group of three items: 'Recreation', 'HE energy production', and 'Agriculture'. Another arrow points from 'Biological Integrity' to a larger group of seven items: 'Natural resources', 'Storage', 'Wildlife', 'Fish & wildlife habitat', 'Vegetation', 'Rare species or habitat', and 'Aquatic life and fish'. A third arrow points from 'Biological Integrity' to a list of ten items on the left side of the slide.
- **Human uses**
 - Recreation
 - HE energy production
 - Agriculture
 - **Biological Integrity**
 - Natural resources
 - Storage
 - Wildlife
 - Fish & wildlife habitat
 - Vegetation
 - Rare species or habitat
 - Aquatic life and fish
 - Human uses
 - Cultural resources
 - Water quality
 - Pollution
 - Aesthetics
 - Fisheries
 - Public water supply
 - CWA Designated Uses
 - Open space
 - Geologic resource

What is Needed to Describe PISFs?

- **A systematic method of determining flow needs for human uses.**
- **A systematic method of determining flow needs for ecological integrity.**
- **A meaningful way to describe stream flow and protected flows.**

How to Describe the PISF?



- EXPLANATION -----
- MEDIAN DAILY STREAMFLOW BASED ON 70 YEARS OF RECORD
 - DAILY MEAN DISCHARGE
 - ESTIMATED STREAMFLOW
 - + Flow at station affected by ice
 - 2-Year Recurrence Interval
 - 99% Flow duration
 - 7-day, 10-year low flow

Natural Flow Paradigm

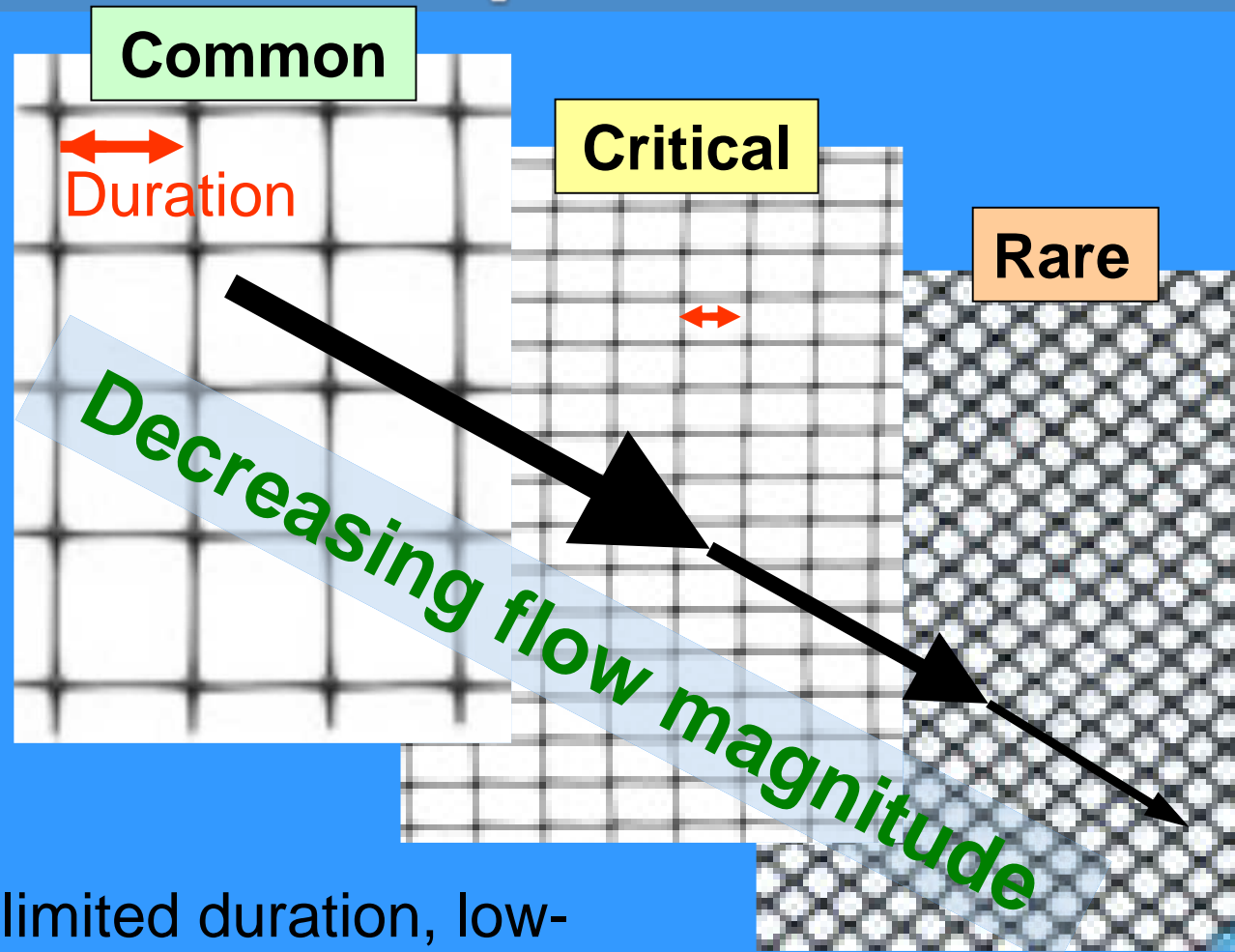
- NFP = aquatic life is adapted to naturally occurring variability.
- How to define the appropriate variability pattern for PISF?
- Describe flow as; **timing, duration, frequency, rate of change** as well as **magnitude**.

Poff NL, et al. 1997. The natural flow regime. A paradigm for river conservation and restoration. *BioScience* 47: 769–784.

How NFP flow components are described in the Lamprey PPISF report

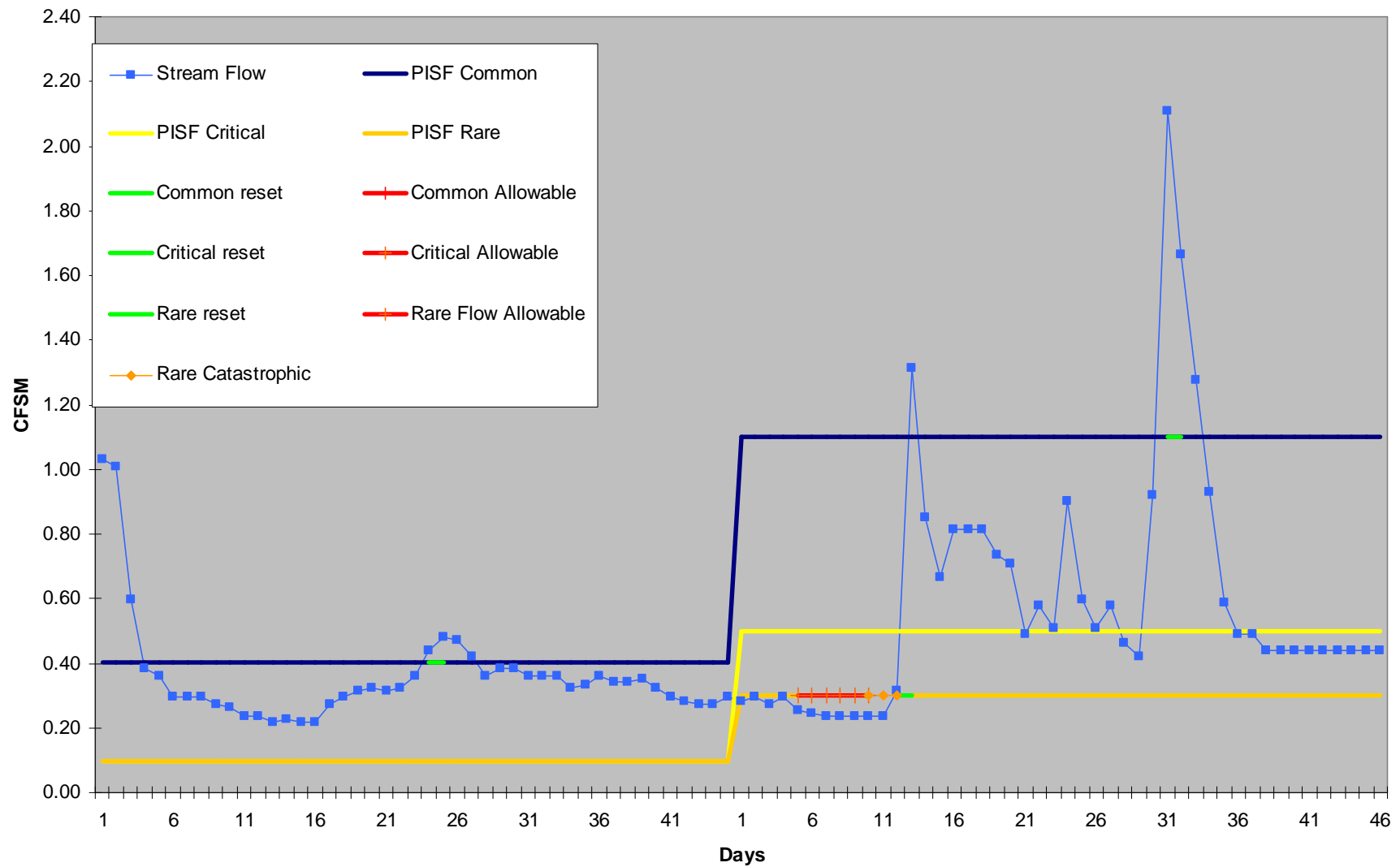
- **TIMING** – Bioperiods – biologically significant divisions of the year.
- **MAGNITUDE** – three levels for each bioperiod.
- **DURATION** – for each magnitude - allowable and catastrophic thresholds marking when flows go too low for too long.
- **FREQUENCY** – used either to 1) define the duration, or 2) specified number of events for magnitudes.

Pair magnitudes with their natural durations at historically-significant frequencies



Lets only limited duration, low-flows get through

Souhegan River Stream Flow versus PISF magnitude and durations



Flow Dependent Protected Entities

**INSIREAM PUBLIC USES, OUTSTANDING
CHARACTERISTICS, AND RESOURCES OF THE LAMPREY
RIVER AND PROPOSED PROTECTIVE FLOW MEASURES FOR
FLOW DEPENDENT RESOURCES**

FINAL REPORT

NOVEMBER 2006



Flow Dependent Protected Entities

Recreation

- Boating
- Fishing
- Swimming

Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
- High Energy Riverbanks
- River Rapids

RTE Plants

- Water Marigold
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Small-crested Sedge
- Slender Blue Flag
- Climbing Hempweed

RTE Wildlife

- Wood Turtle
- Spotted Turtle
- Blanding's Turtle
- Pied Billed Grebe
- Osprey
- Bald Eagle
- Sedge Wren

Aquatic Life and Habitat

- Fish and Fish Habitat
- Mussels
- Insects
- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

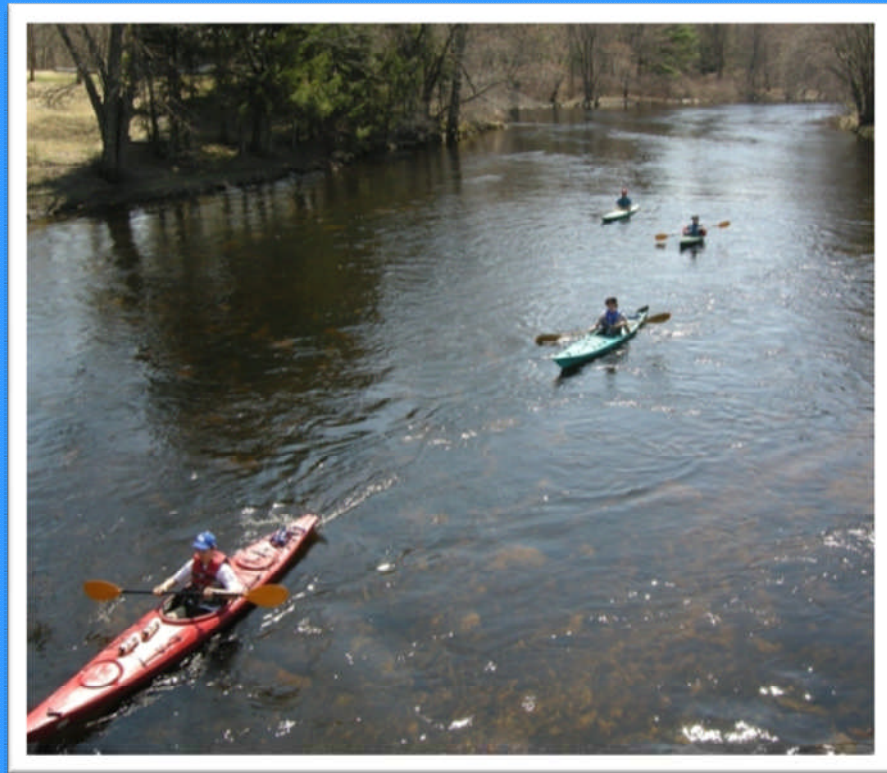
Public Water Supply

Recreation

Recreation Protected Entities:

- Boating
- Fishing
- Swimming

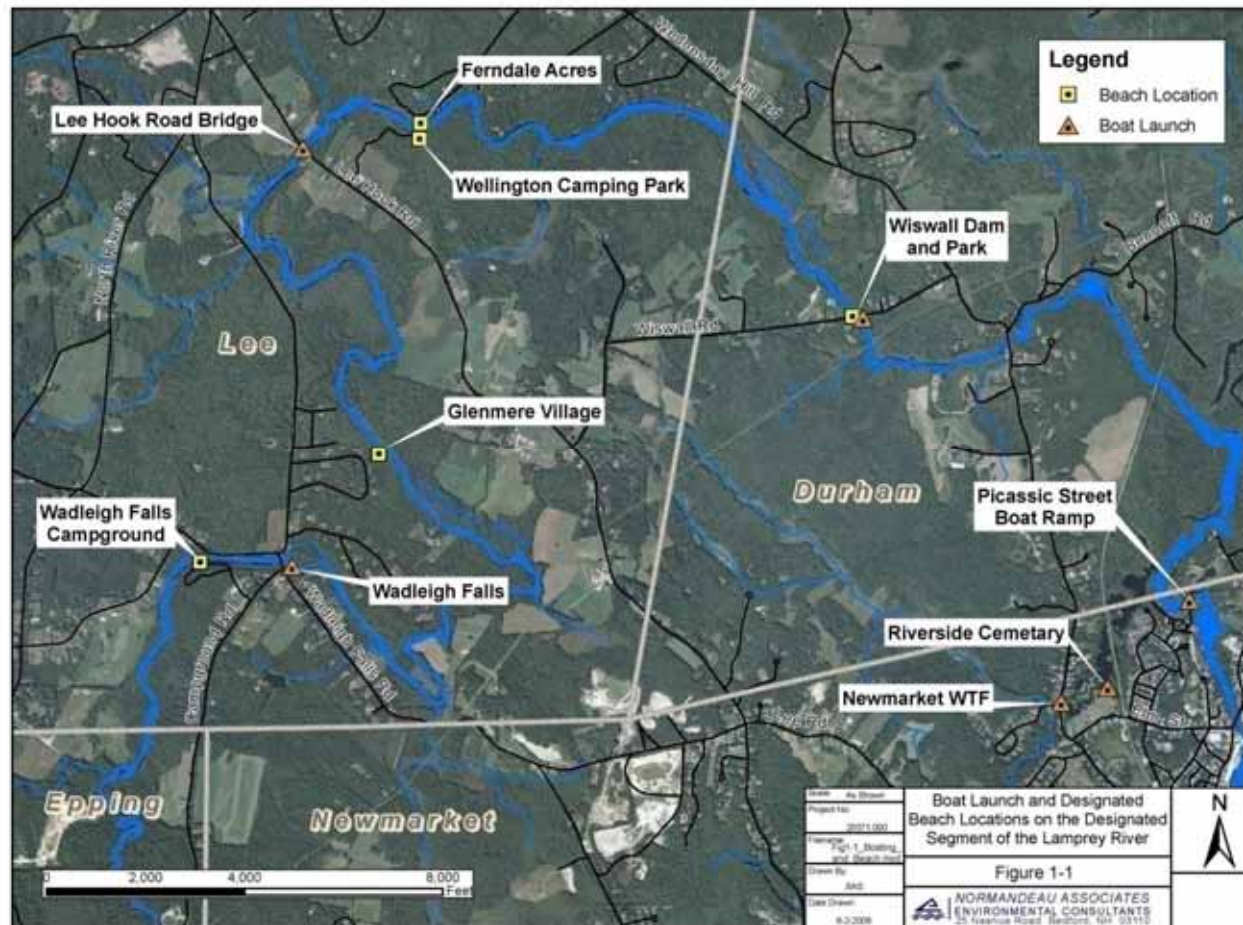
Noted as important resources for supporting designation in 1990.



Recreation - Boating

- **Evaluated by field surveys (including swimming survey) with 37 responses.**
- **Surveys performed in spring, summer and fall of 2006 and spring 2007.**
- **Surveyed participants of 2006 Lamprey River Canoe (& Kayak) race.**
- **Visited popular boat launch locations on upper and lower portions of the designated segment.**

Recreation - Boating



Boating Survey Results

Lower Lamprey (Designated):

- Most paddle more than 2 times a year, during spring, summer and fall.
- Paddlers from Durham and Dover NH.
- Monitor flow by word of mouth or visual.
- Paddle flatwater sections upstream of falls or dams.
- Minimum flow should be about what was observed on July 1 2006 (1.36 cfs or 249 cfs).
- Attraction of river: quiet, lack of development, beautiful scenery and fishing.

Recreation - Boating

Other sources of information on recommended flow levels for paddling Lamprey River:

- AMC Guidebook Discover Southern New Hampshire by Monkman and Monkman (2002) suggests that running the Lamprey at flows below 200 cfs (1.09 cfs) should not be attempted.**
- Survey respondents from 2006 Lamprey Canoe Race indicated that flows should have been higher than what they were (154 cfs, 0.84 cfs) the day of the race.**
- Indicator of water level – flow over rapids/riffles downstream of Lee Hook Road Bridge. If you can pass this with a canoe, whole trip usually good.**

Recreation - Boating

Passage of canoes and kayaks through rapids downstream of Lee Hook Road bridge observed in April and May 2008 at flows of 425 and 205 cfs.



May 14 2008 Q = 205 cfs



April 19 2008 Q = 425 cfs

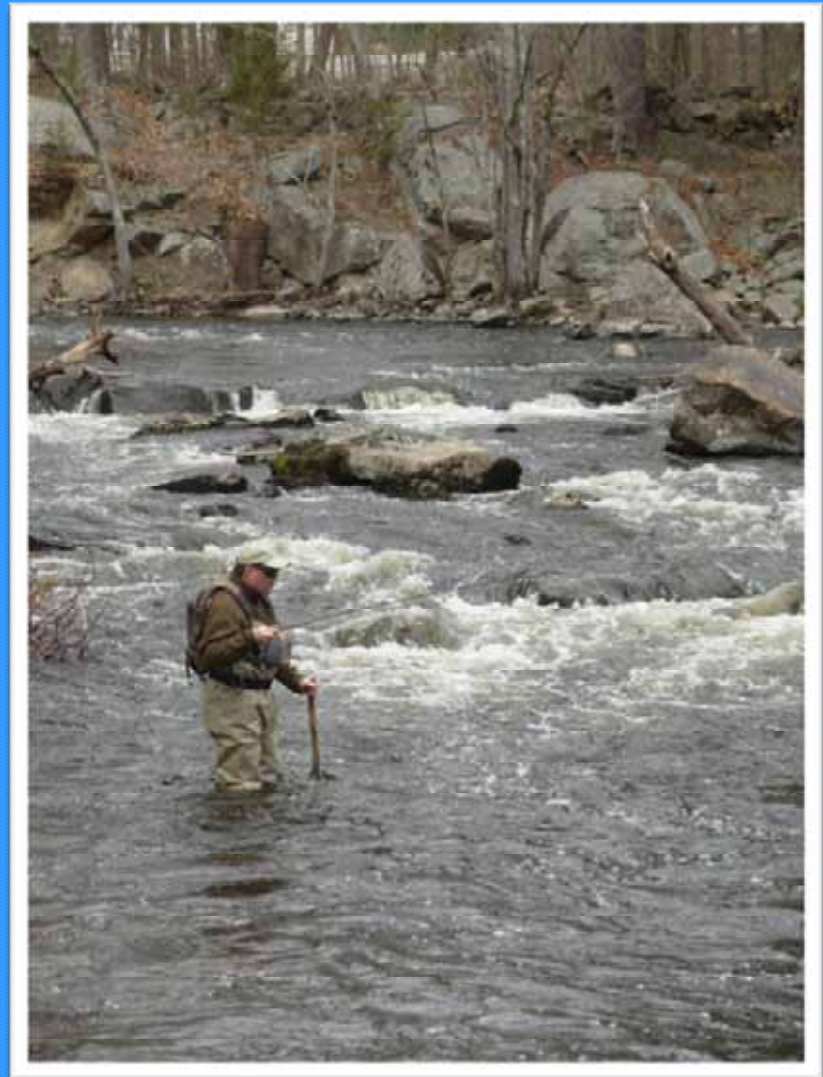
Recreation - Boating

Protected Instream Flow for Recreational Boating:

- Paddling through rapids flow dependent, flatwater paddling not flow dependent, but levels controlled naturally or artificially.
- Observed flow conditions at rapids sections suggest flows greater than 200 cfs (1.1 cfs) needed to navigate rapids.
- Based on field crew observations a flow of 275 cfs (1.5 cfs) proposed as PISF for whitewater recreational boating.

Recreation - Fishing

- Fishing on the Lamprey River is flow dependent.
- No recreational fishing survey performed.
- Instream flow values from MesoHABSIM protective of fish and fishing recreation resource.

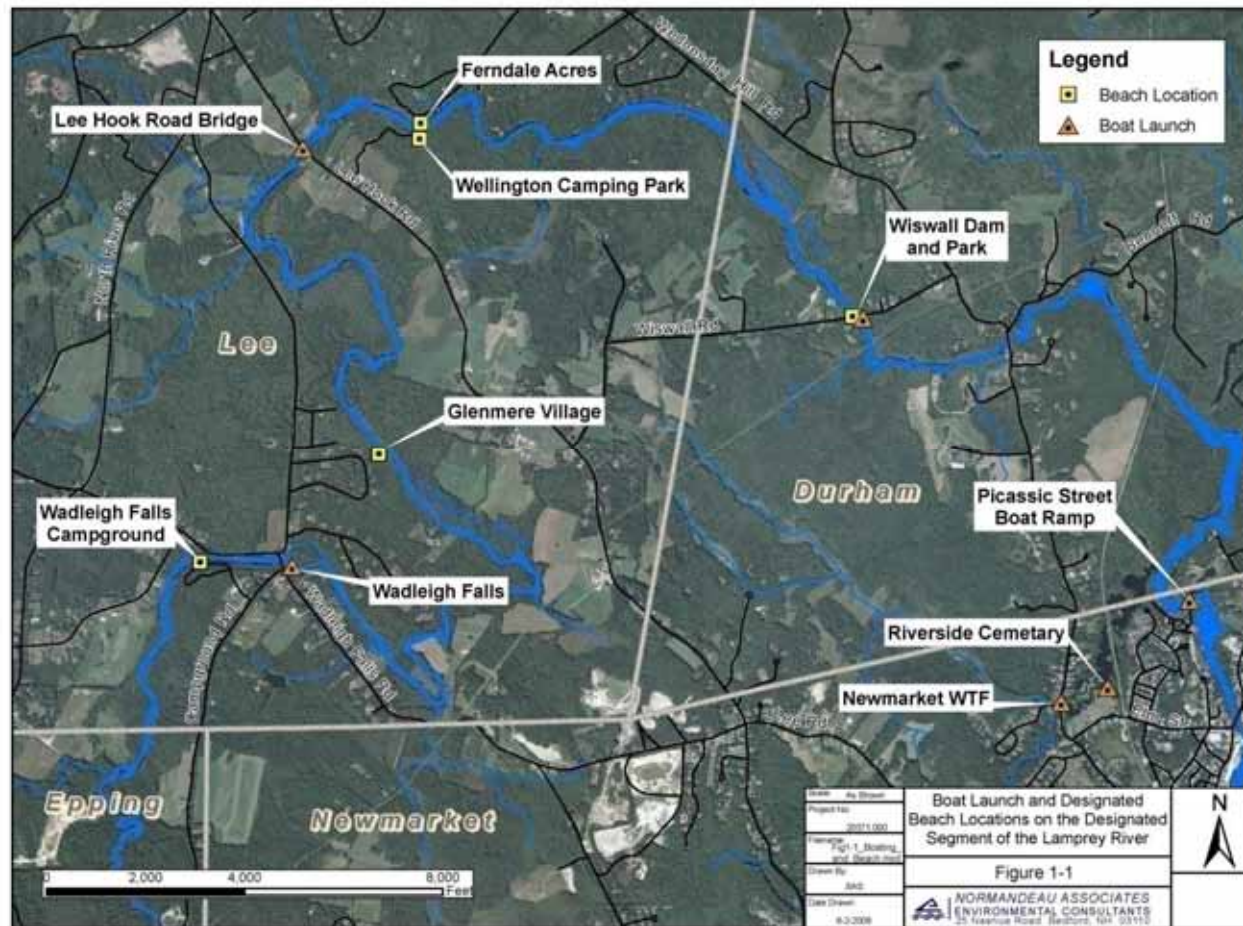


Recreation - Swimming

- Swimming popular recreational activity on the river.
- Recreational swimming assessed by surveys at four designated beaches and two swimming holes in July and August 2006. Total of 24 responses.



Recreation - Swimming



Swimming Survey

The survey included questions regarding:

- Use of the river**
- Frequency of use**
- Favorite swimming locations**
- Preferred flow conditions or levels,
sources of information on swimming
conditions.**

Swimming Survey Results

- Months of use ranged from April to October, most activity centered June to August during periods of hot weather.
- Few people monitor flow conditions other than by driving by or checking when they arrive at their campsite.
- Outside of large-scale drought or flood events, swimmers will use the river when it is convenient and it is warm enough.

Recreation - Swimming

- **Most popular sections of river used for swimming are impounded by dams or bedrock falls.**
- **Due to control of water levels in these sections, they are less flow dependent than in other sections and for other recreational uses.**
- **Since swimming conditions are dependent on multiple variables a specific instream flow value cannot be established or proposed.**

Flow Dependent Protected Entities

Recreation

- Boating
- Fishing
- Swimming

Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
- High Energy Riverbanks
- River Rapids

RTE Plants

- Water Marigold
- Sharp-flowered Mannagrass
- Knotty Pondweed
- Small-crested Sedge
- Slender Blue Flag
- Climbing Hempweed

RTE Wildlife

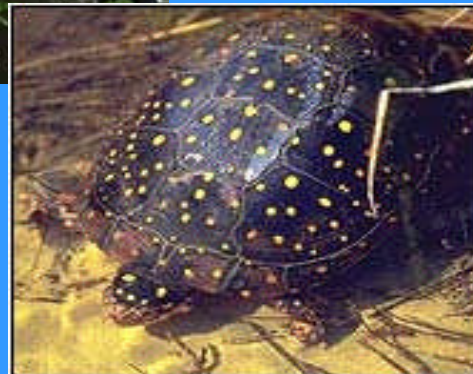
- Wood Turtle
- Spotted Turtle
- Blanding's Turtle
- Pied Billed Grebe
- Osprey
- Bald Eagle
- Sedge Wren

Aquatic Life and Habitat

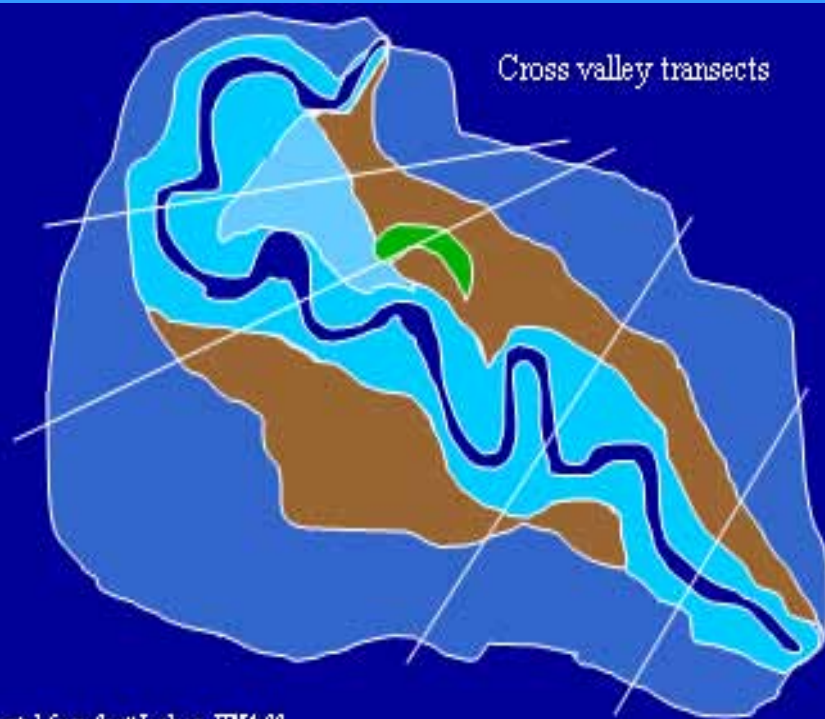
- Fish and Fish Habitat
- Mussels
- Insects
- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

Public Water Supply

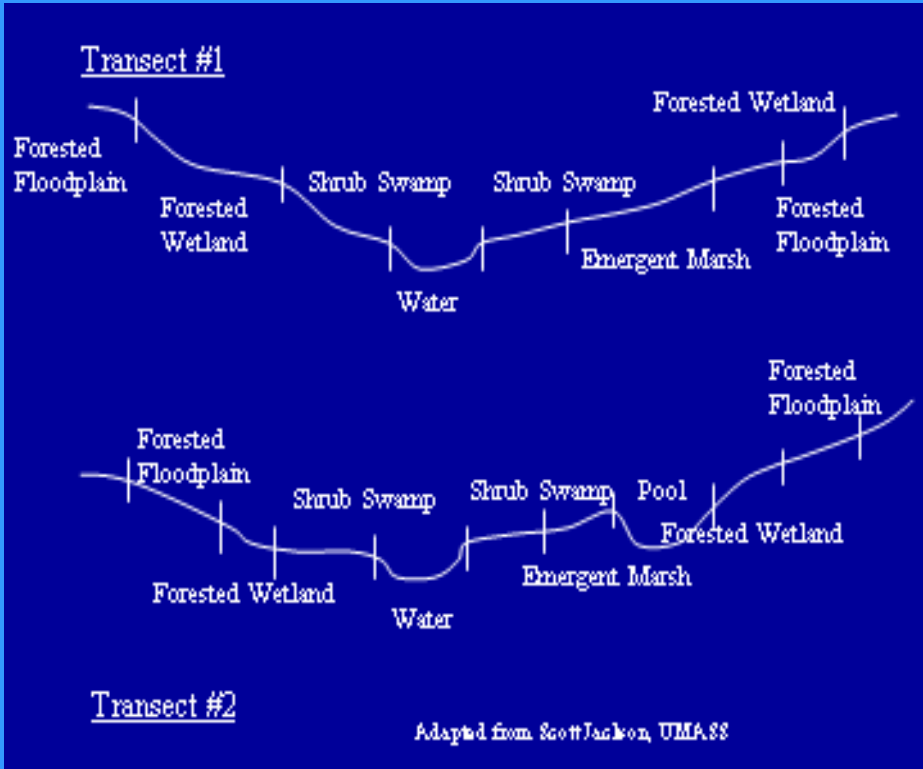
Riparian Plant Communities and Associated Flora and Fauna



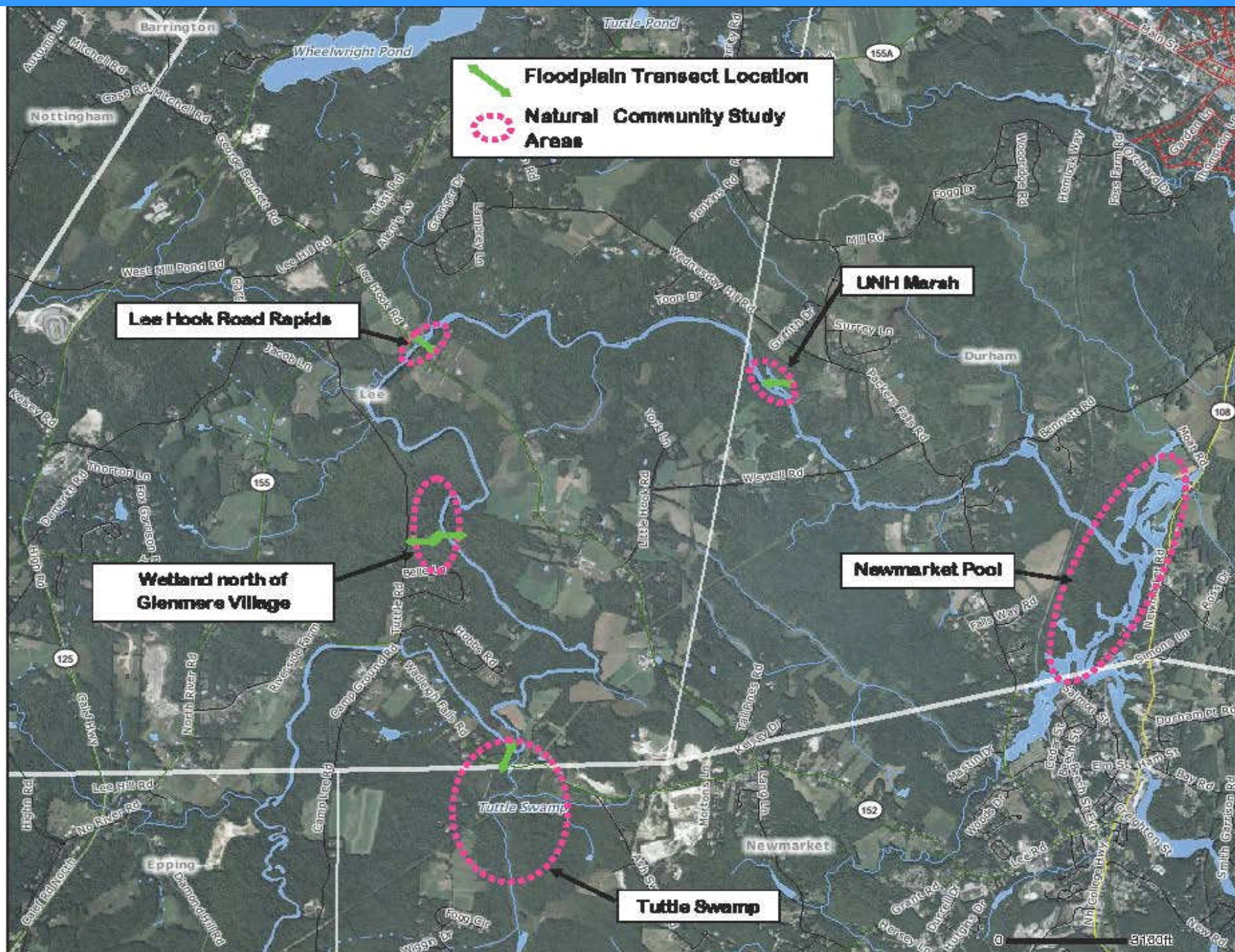
Transect Method

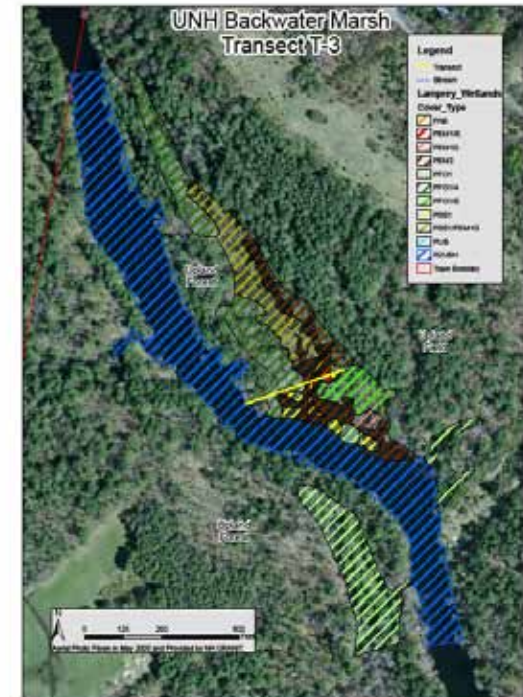
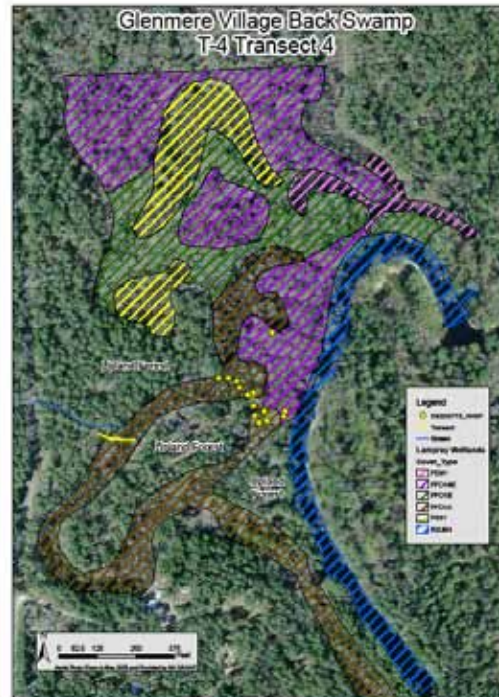


Adapted from Scott Jackson, UMASS

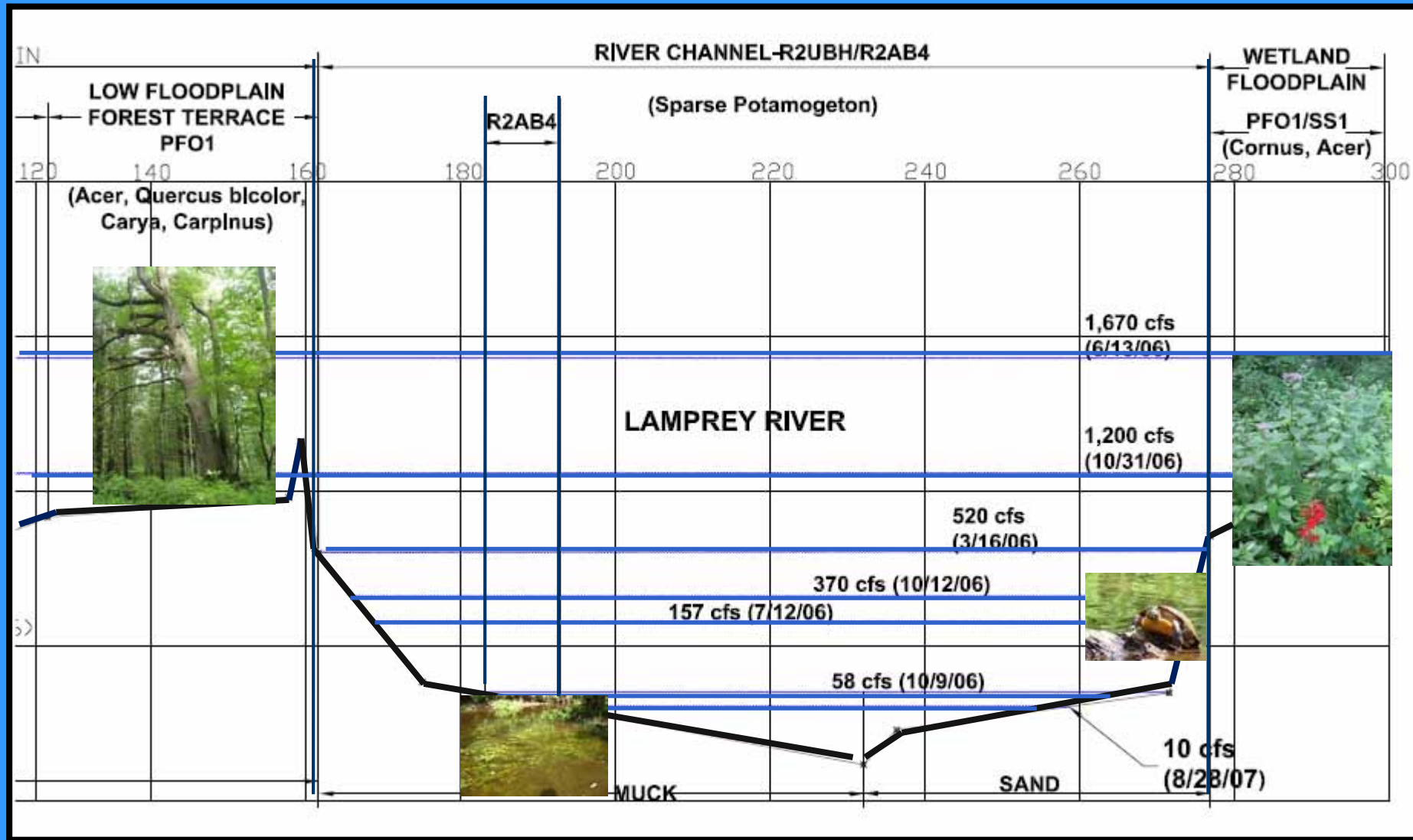


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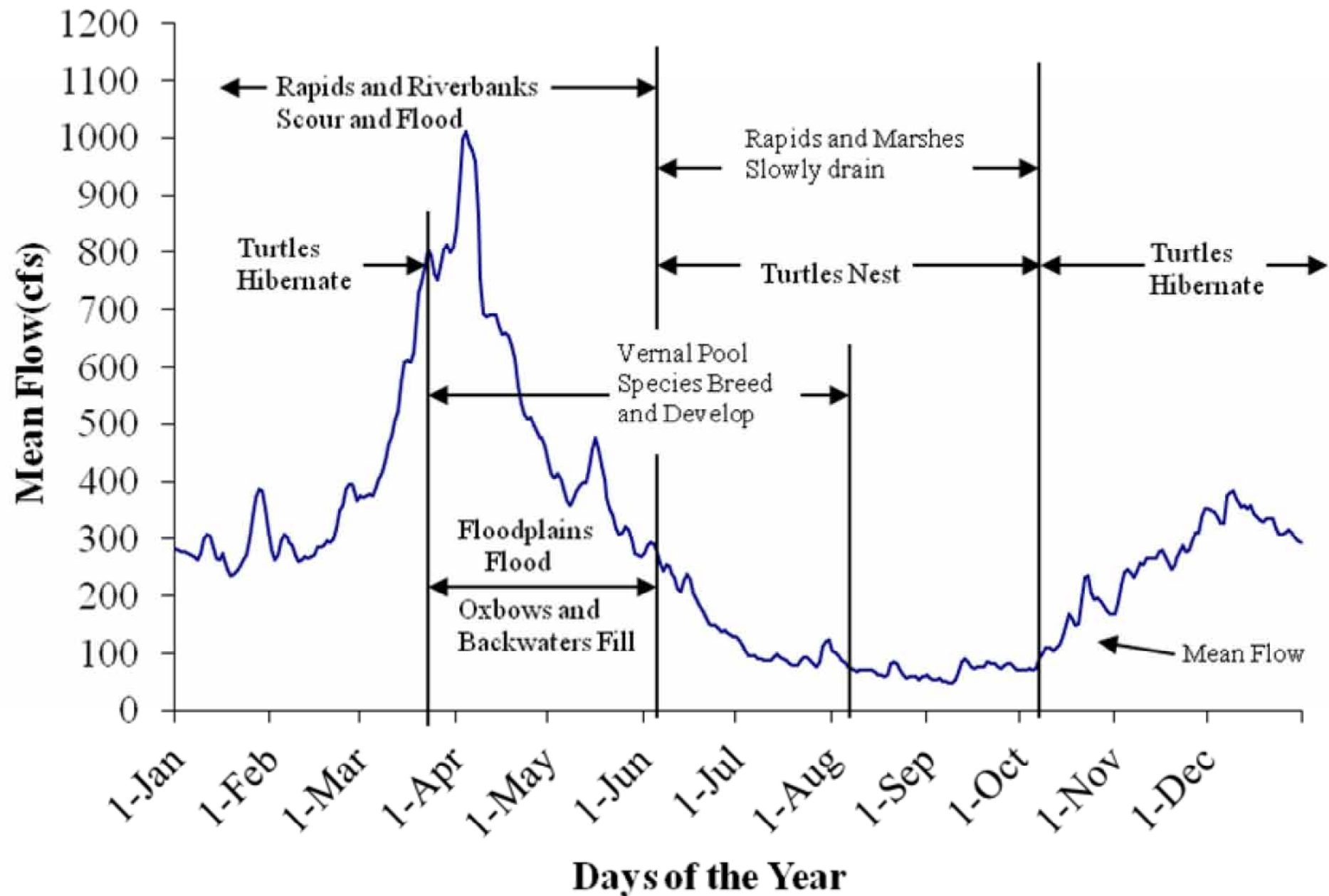


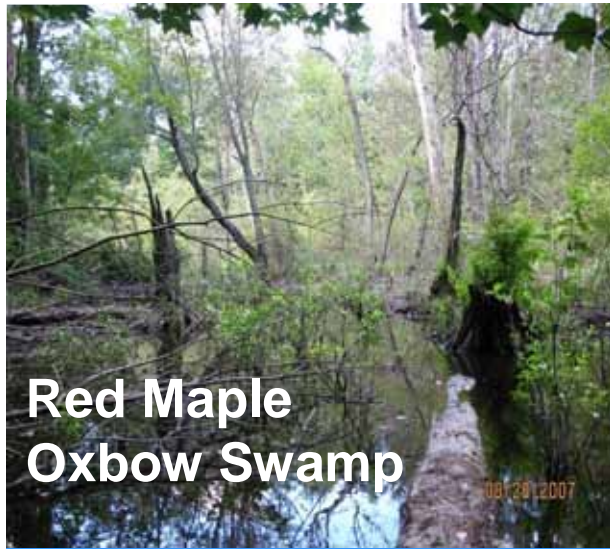


T-1 Tuttle Swamp Transect (excerpt)



Wildlife and Natural Community Bioperiods





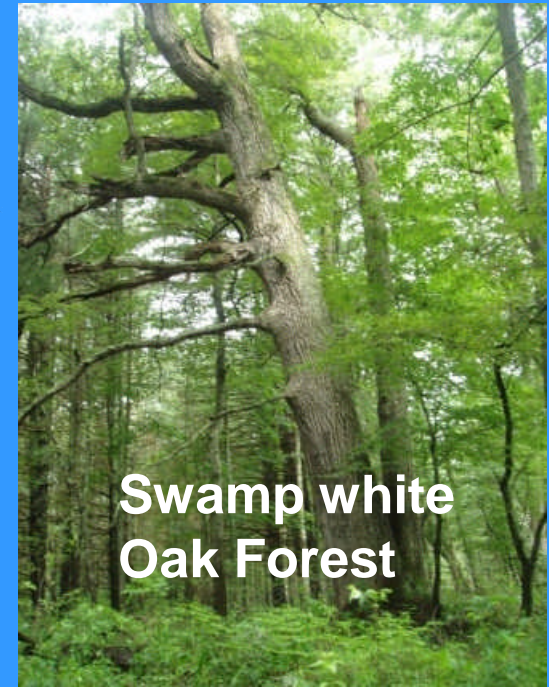
Red Maple
Oxbow Swamp

Floodplain Forests and Oxbow Wetlands Requiring Periodic Flooding

PISF

- Flows greater than 500 cfs every one to three years
- flows greater than 1,500 cfs once every five years

**Don't Create Floods, but Don't
Prevent Them Through
Management!**



Swamp white
Oak Forest



Silver Maple
Floodplain Forest

Flood Sensitive Plants and Animals

Daily flows:

< 500 cfs in June, July and October

< 60 cfs in August and September

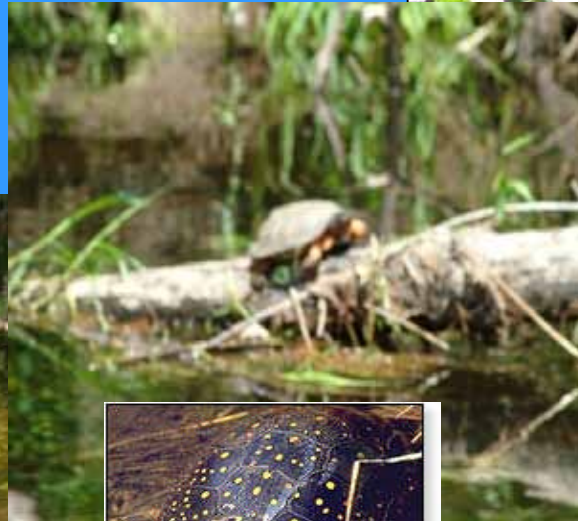
**Not a Flood Control
Recommendation!**



Turtle and
Bird Nestlings



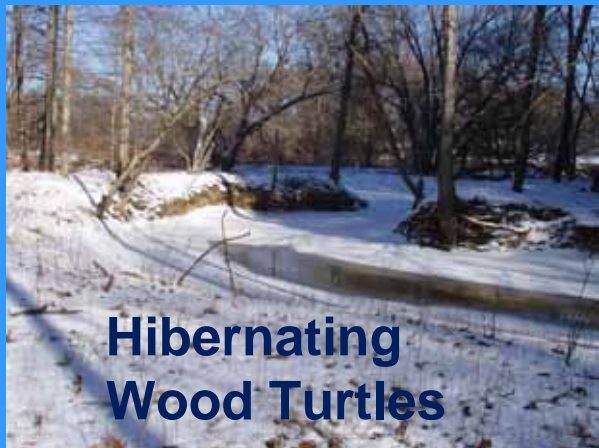
Flowering
Aquatic
Plants



Floodplain
Vernal Pool
Larvae

Plants, Animals and Communities Requiring Minimum Winter, Spring, or Summer Flows

- 130 cfs December through March
- 100 cfs April through June
- 10 cfs during July
- winter, daily flows > 50 cfs
- Winter flows of 500 cfs for > one week.



Fish-eating Raptors

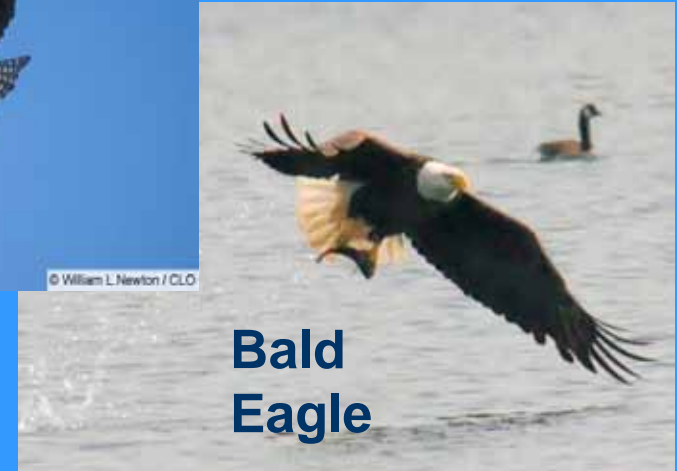
PISF

- Protective flows for GRAF Fish (Generic Resident Adult Fish)

Osprey



Bald Eagle



Plants and Animals of Impoundments

Protective Water Levels (not flows)

- summer water levels within 18 inches of mean



Flow Dependent Protected Entities

Recreation

- Boating
- Fishing
- Swimming

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Aquatic Life and Habitat

- Fish and Fish Habitat
- Mussels
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- T/E Bridled Shiner
- Banded Sunfish
- Endangered Brook Floater

Public Water Supply

Lamprey River MesoHABSIM Application



Lamprey River Watershed

Legend

Lamprey loggers

- Loggers Missing
- Loggers Recovered

— Major Roads

— lamprey_river

Watershed Elevations

feet

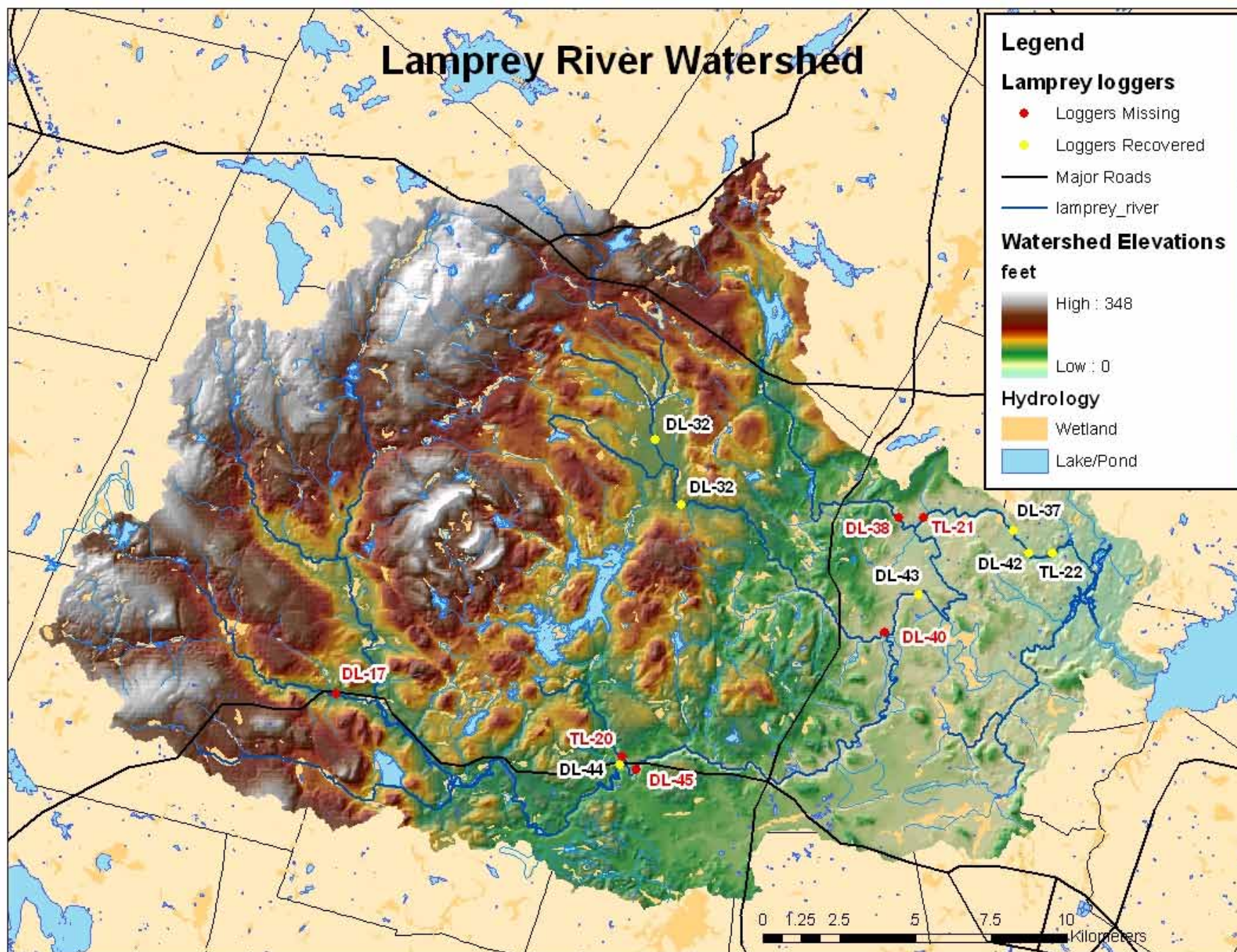
High : 348

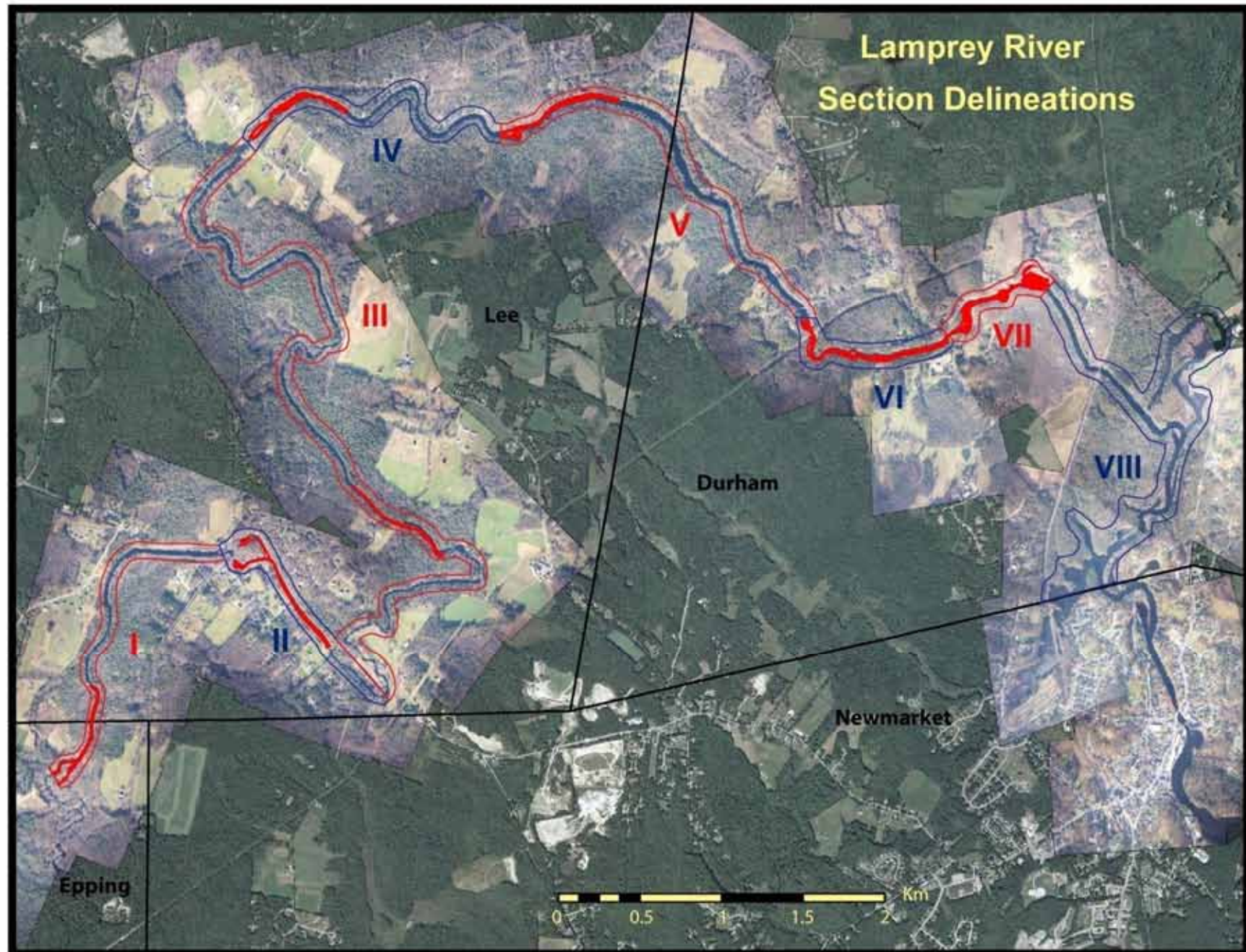
Low : 0

Hydrology

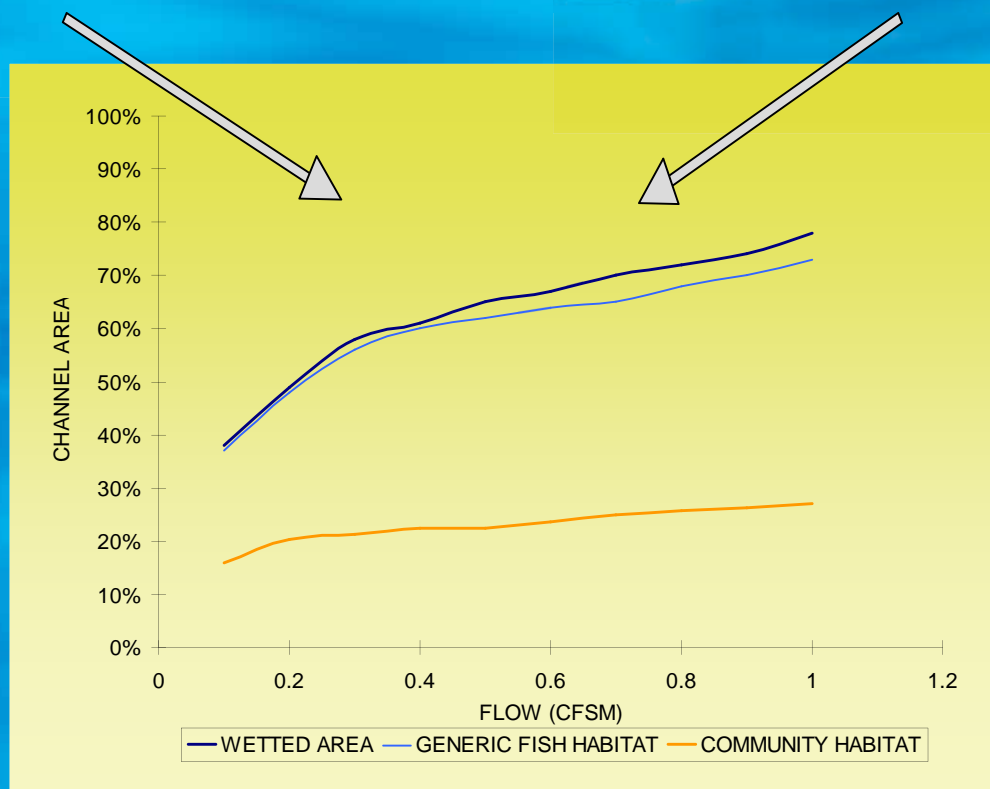
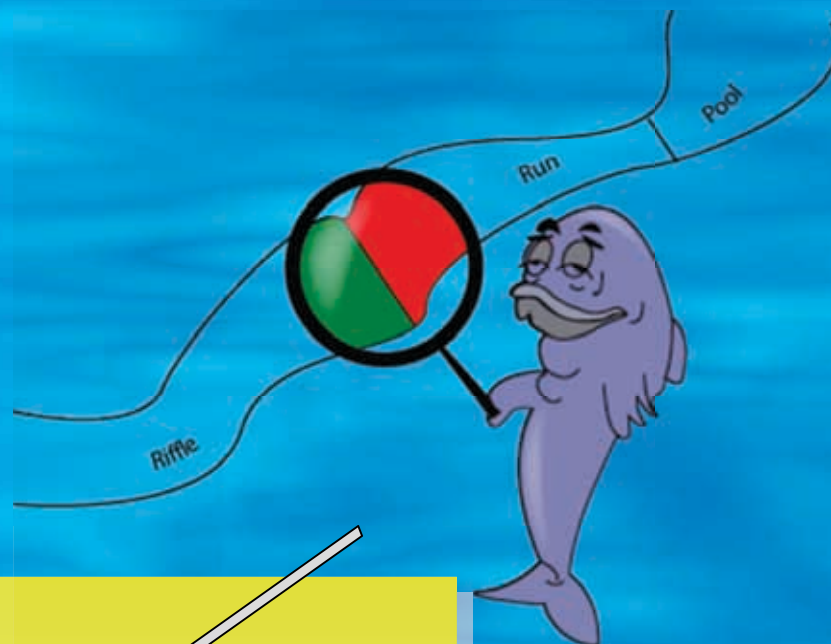
Wetland

Lake/Pond





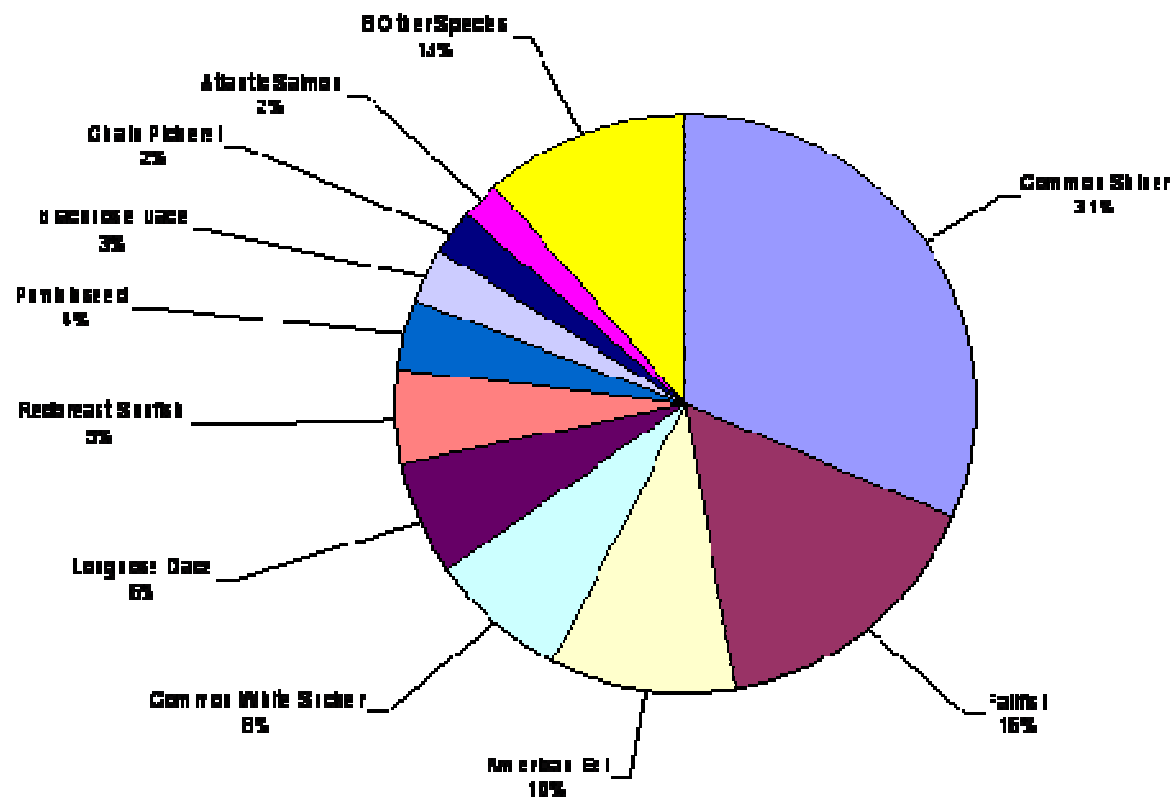
MesoHABSIM



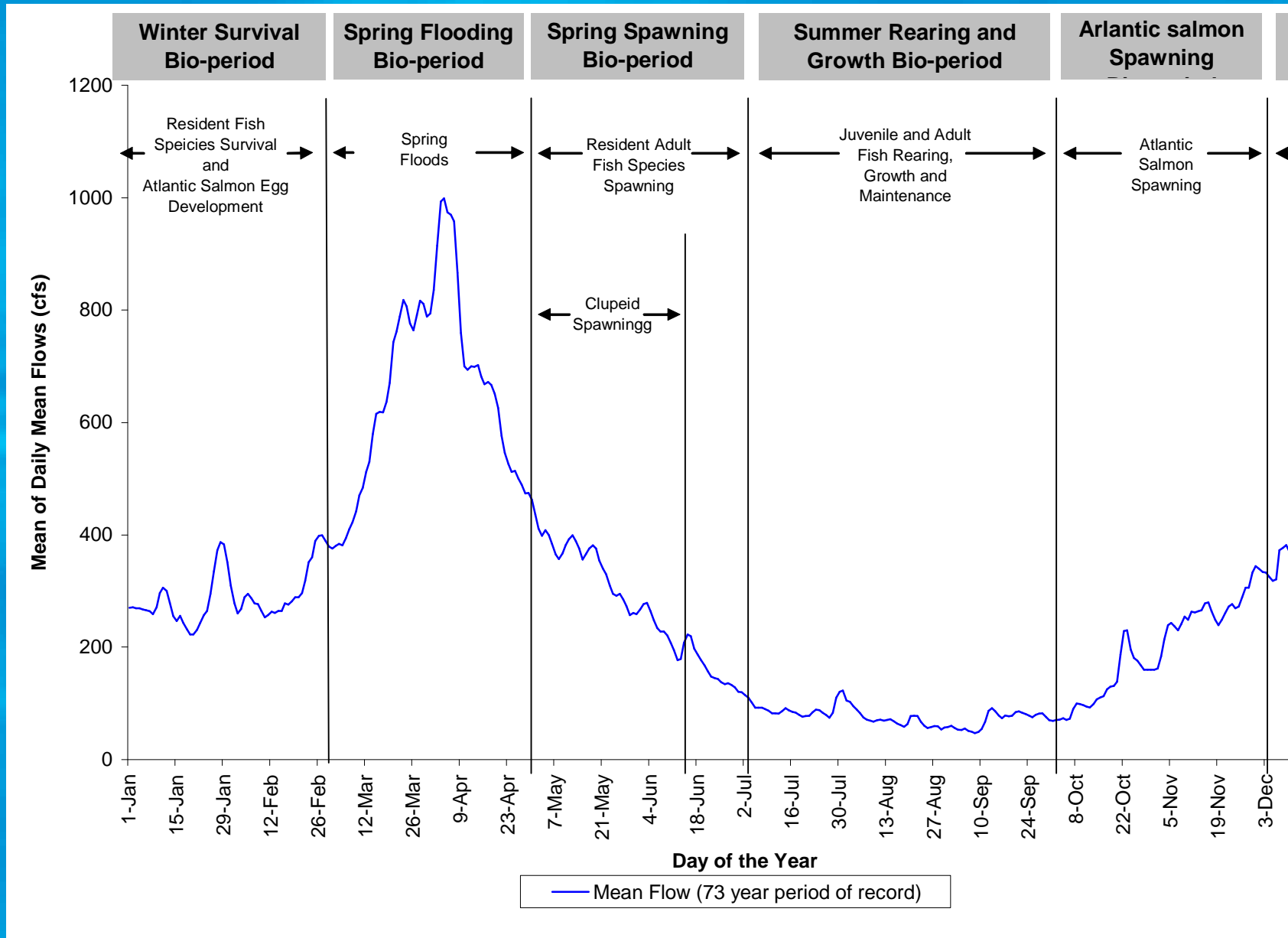
MesoHABSIM Process

- 1. Biological targets and indicators**
 - a. Reference fauna
 - b. Bioperiods
 - c. Indicators
- 2. Biological filters**
 - a. Literature based criteria
 - b. Empirical data
- 3. Instream Habitat classification**
 - a. Delineation
 - b. Evaluation
 - c. Upscaling
- 4. Adjusting biophysical template**
 - a. Identify habitat deficiencies
 - b. Simulate habitat improvements
- 5. Time Series Analysis**
- 6. Interpretation and Application**
 - a. Restoration recommendations
 - b. Flow management criteria

Target Fish Community



Bioperiods



Species Selected for Habitat Modeling (summer)

Fallfish



Redbreast sunfish



American Eel

Common shiner



Longnose dace



White sucker



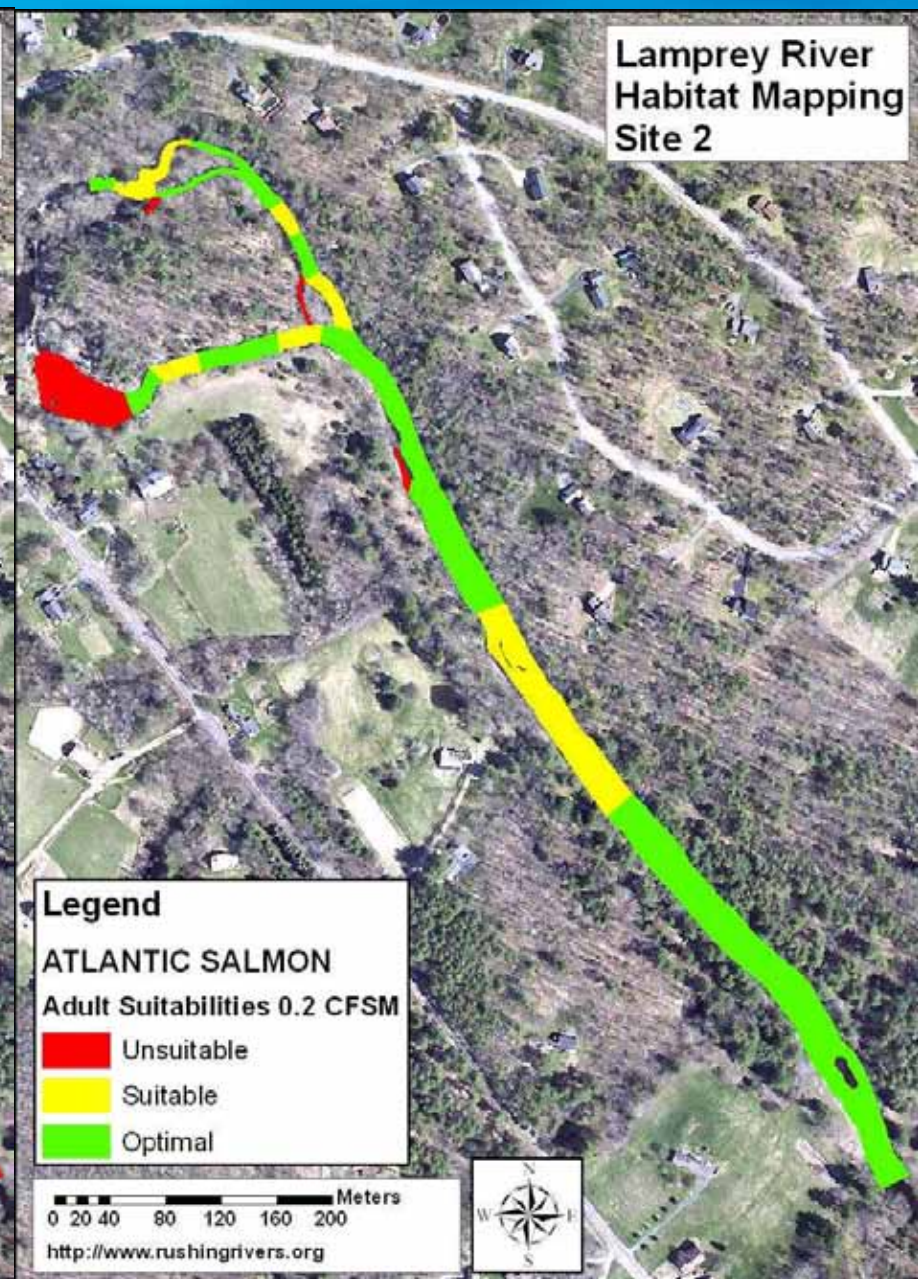
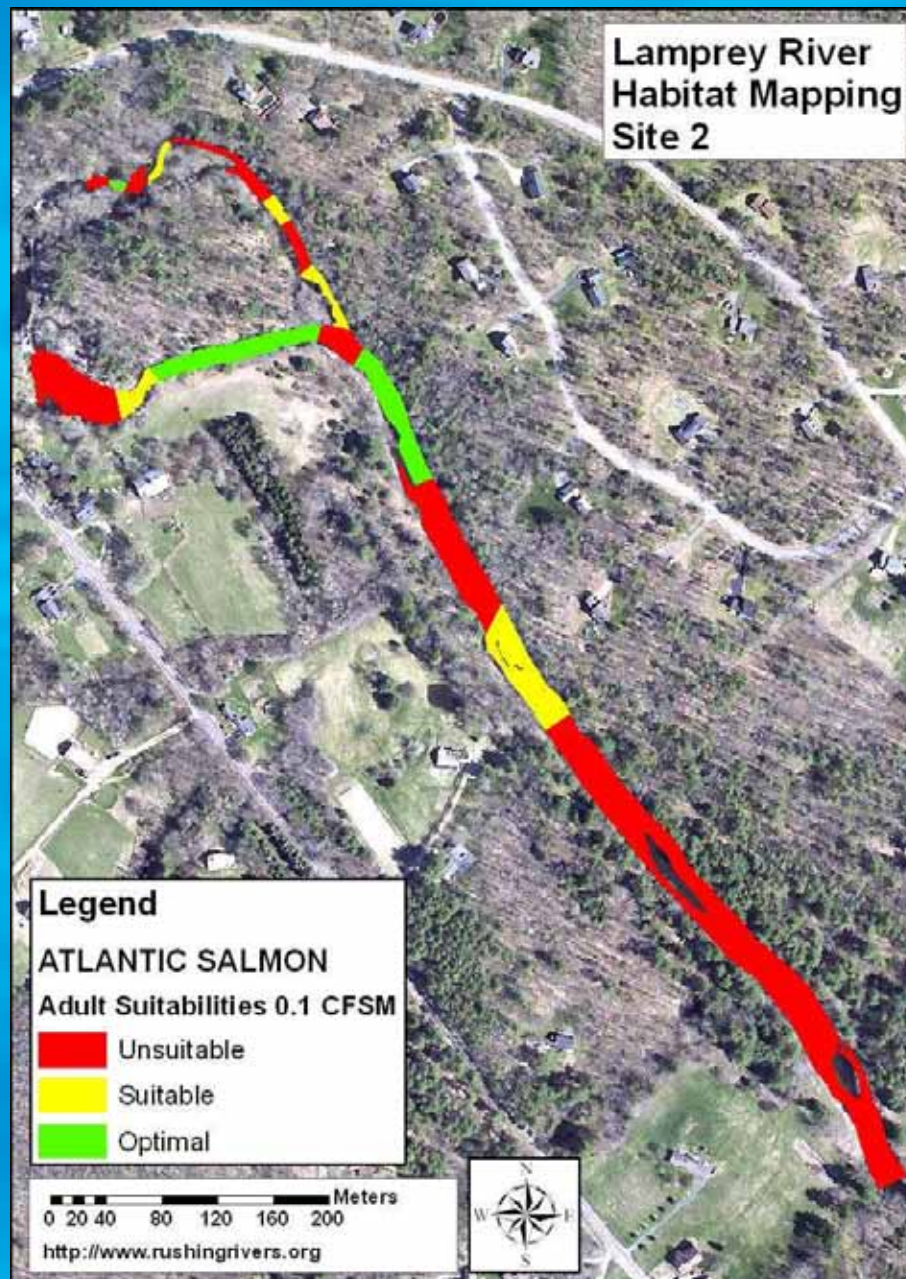
Blacknose dace



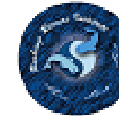
Atlantic salmon



Habitat Maps

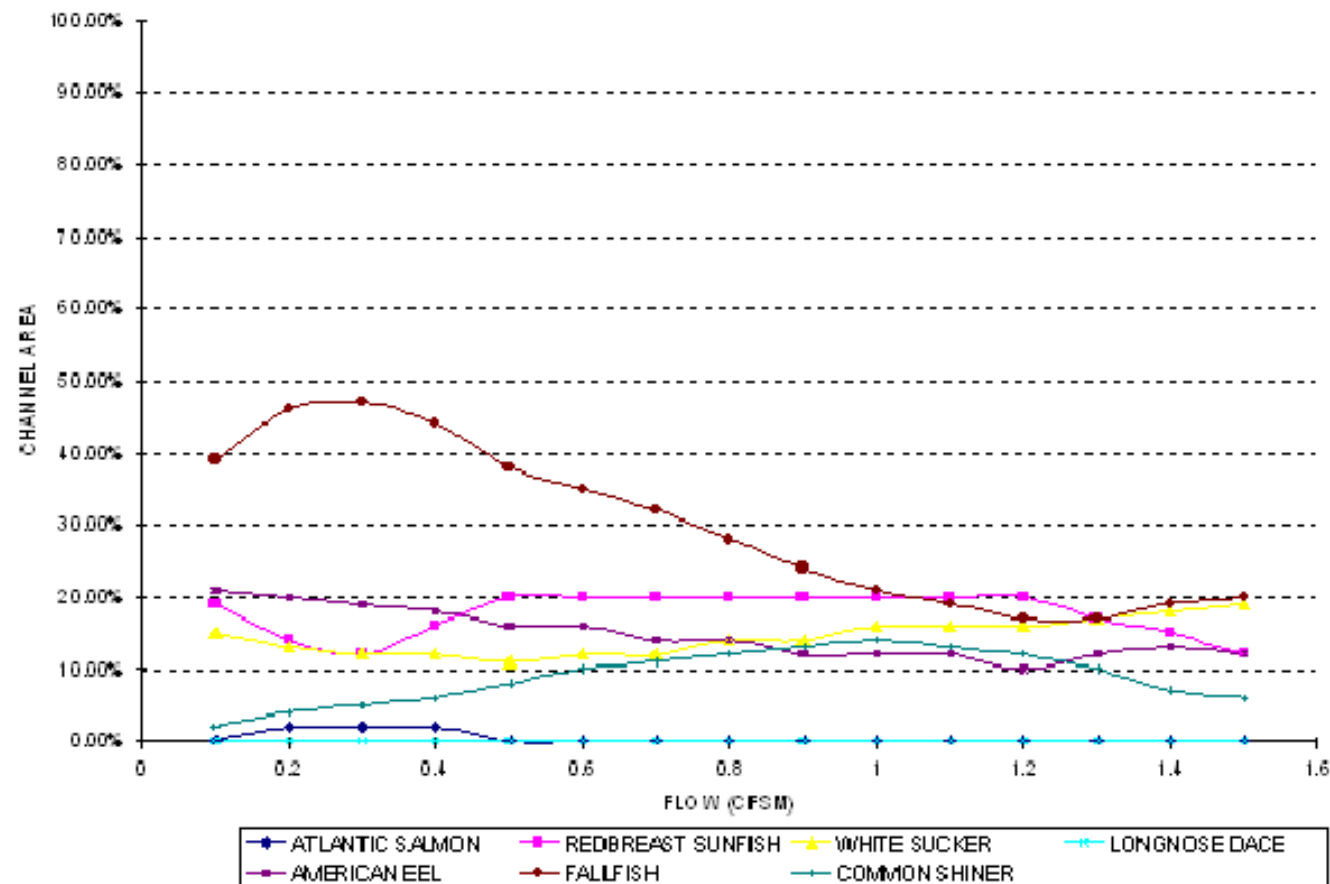


Effective Habitat for Fish



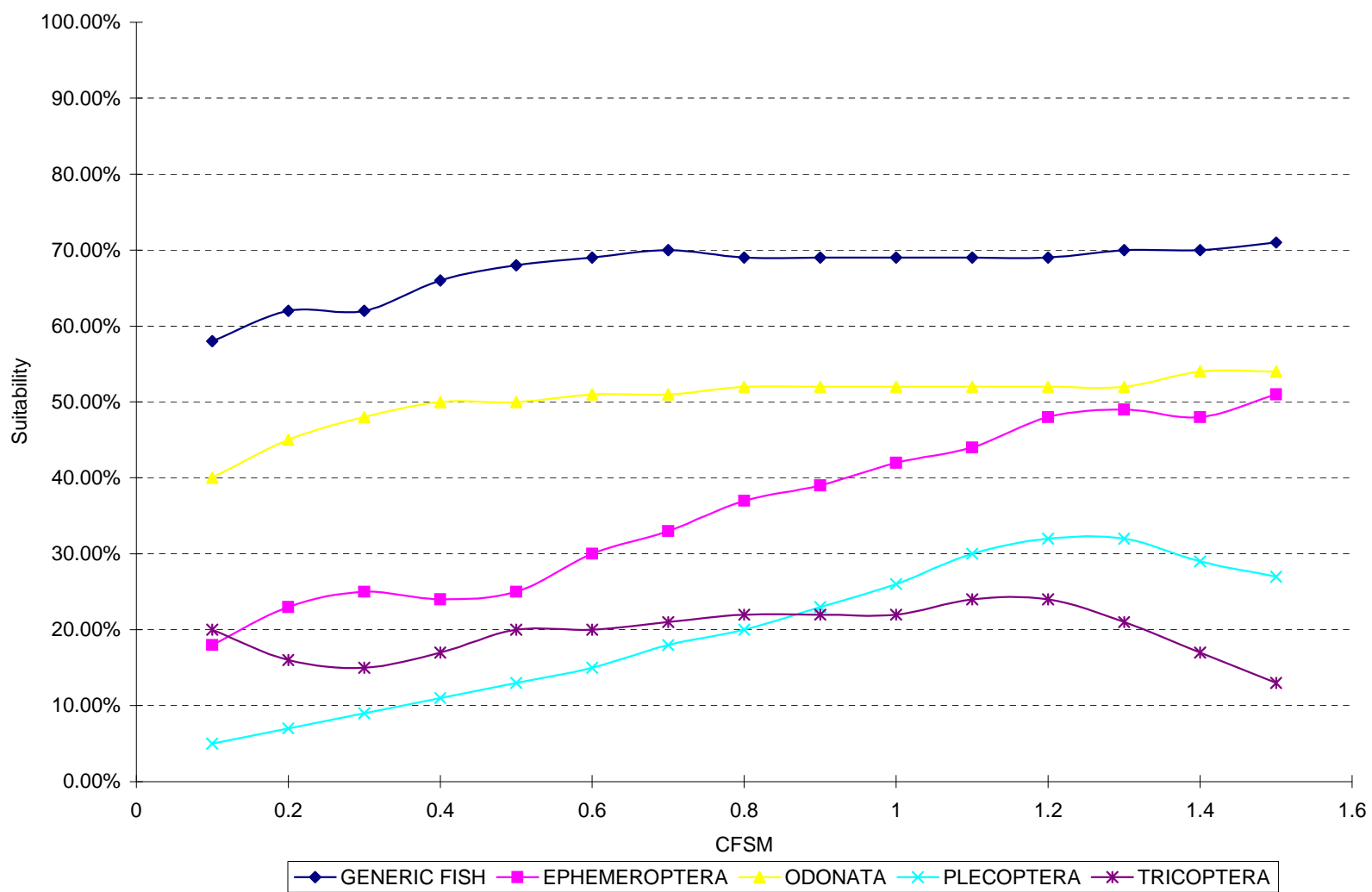
Suitability Curve(s) for Whole Project

Project: Lamprey River AIC
Effective Habitat

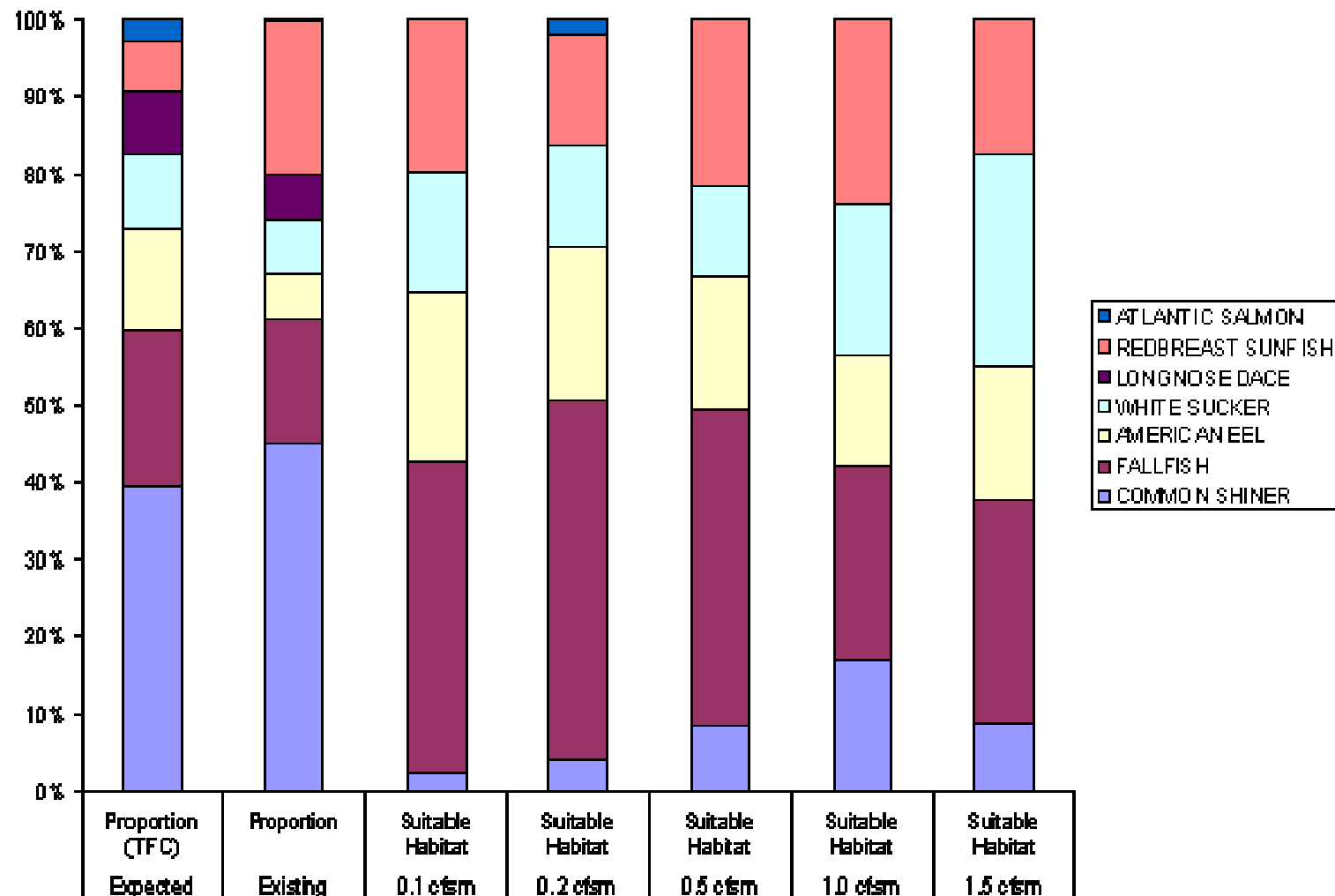


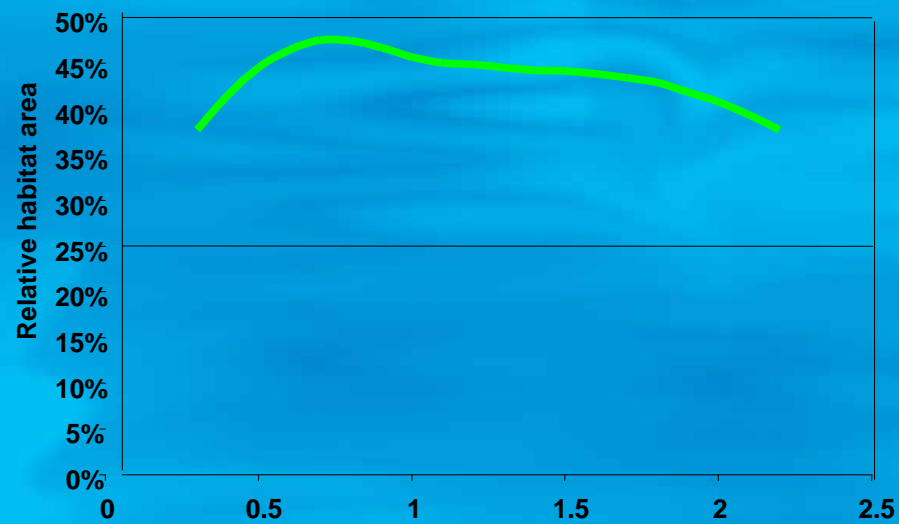
Suitability Curve(s) for Whole Project

Project: Lamprey River Bugs AIC
Effective Habitat

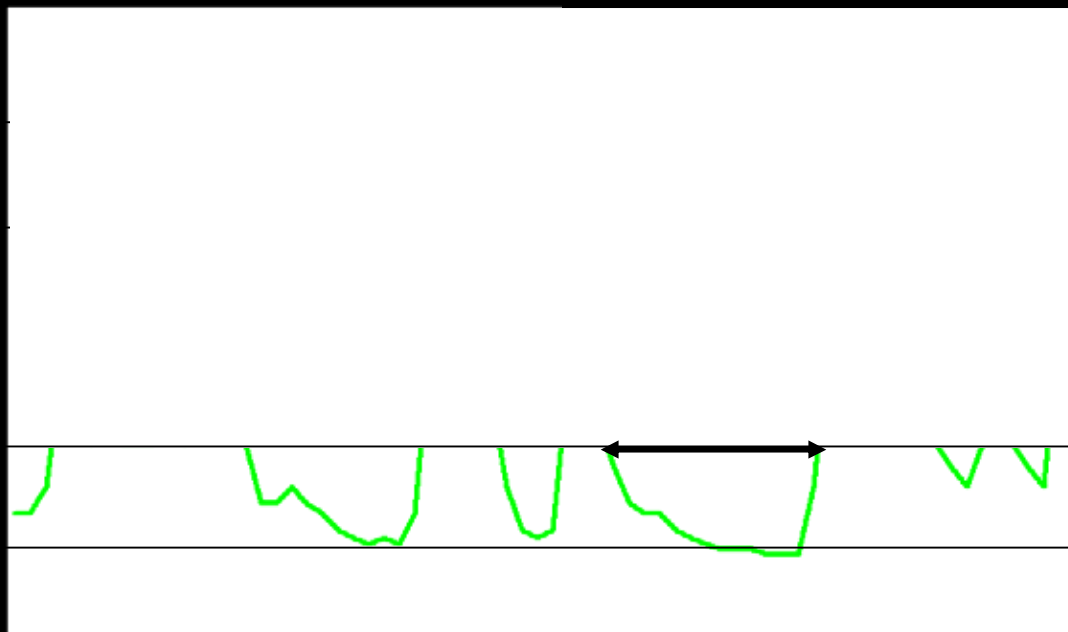
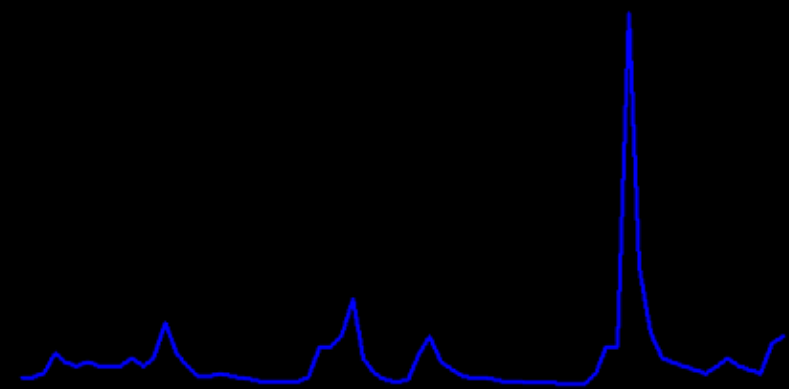


Habitat vs. Fish Community





+



Flow Thresholds

The common flow:

- corresponding to the highest habitat magnitude that occurs with regular frequency.
- this flow can be recognized by the fact that it is not exceeded very often and that the incrementally higher habitat thresholds increase the cumulative frequency of events under-the-threshold at much lower rate than for the common threshold.
- near optimal habitat availability conditions.

Flow Thresholds

The rare flow:

- corresponding to the highest habitat magnitudes that occur far apart in time.
- exceeded very often .
- incrementally higher habitat thresholds increase the cumulative frequency of events under-the-threshold at much higher rate.
- habitat availability is severely reduced and very uncommon.

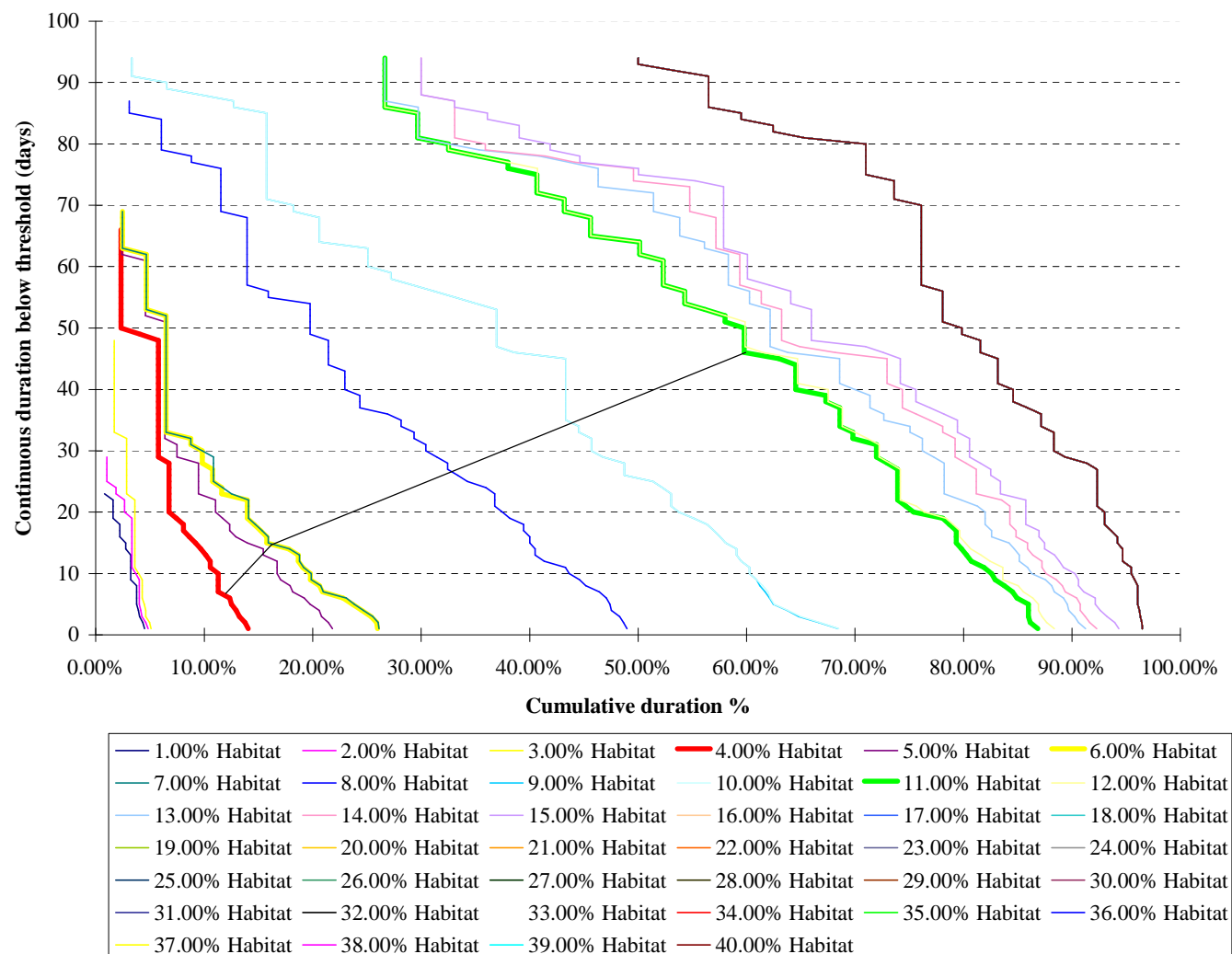
Flow Thresholds

The critical flow:

- corresponding to the first habitat threshold higher than that of the rare habitat magnitude.
- less habitat availability than that provided by the common flow, but this habitat magnitude is not unusual.

Flow Duration Threshold

- **Allowable** – consecutive days with flow below protected magnitude for ordinary conditions – no flow management.
- **Catastrophic** - consecutive days with flow below protected magnitude for unacceptable conditions – trigger management.
- **Persistent** – longer then allowable, but shorter then catastrophic - trigger management after 3rd consecutive year.



Fish PISF

Bioperiod	Rearing & Growth	Salmon Spawning	Overwintering	Spring Flood
Approximate dates	July 5 - Oct. 6	Oct. 7 - Dec. 8	Dec 9 - Feb. 28	March 1 - May 4
Indicator	Common shiner	Atlantic Salmon	Flow	Flow
Watershed area (mi ²)	183	183	183	183
Common flow (cfs)	110	90	237.9	622
Common flow (cfsm)	0.60	0.49	1.30	3.40
Allowable duration under (days)	46	17	20	14
Catastrophic duration (days)	81	55	57	42
Critical flow (cfs)	22	40	109.8	238
Critical flow (cfsm)	0.12	0.22	0.60	1.30
Allowable duration under (days)	15	11	10	10
Catastrophic duration (days)	32	33	37	19
Rare flow (cfs)	16	20	73.2	146
Rare flow (cfsm)	0.09	0.11	0.40	0.80
Allowable duration under (days)	6	6	7	3
Catastrophic duration (days)	28	11	30	9
Bioperiod	Clupeid Spawning		GRAF Spawning	
Approximate dates	May 5 - June 19		June 20 - July 4	
Indicator	Min	Max	Min	Max
Watershed area (mi ²)	183	183	183	183
Common flow (cfs)	143		101	
Common flow (cfsm)	0.78		0.55	
Allowable duration under (days)	13		11	
Catastrophic duration (days)	28		15	
Critical flow (cfs)	62	156	22	156
Critical flow (cfsm)	0.34	0.85	0.12	0.85
Allowable duration under (days)	5		5	
Catastrophic duration (days)	13		10	
Rare flow (cfs)	57	242	16	242
Rare flow (cfsm)	0.31	1.32	0.09	1.32
Allowable duration under (days)	4		2	
Catastrophic duration (days)	10		3	
		GRAF Spawning	Common shiner R&G	

Flow Dependent Protected Entities

Recreation

- Boating
- Fishing
- Swimming

Natural Communities

- Floodplain Forests
- Oxbow/backwater Wetlands
- Vernal Pools
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Aquatic Life and Habitat

- Fish and Fish Habitat
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Public Water Supply

Public Water Supply

Legislated Use of Waters

Laws of 1965 – Chapter 322 - “An Act Relative to Future use of Portions of the Waters of the Lamprey River and/or its Tributaries for Public Water Supplies....”.

Grants the Towns of Durham, Epping, Lee, Newmarket and Raymond the use of the waters of the Lamprey River and its tributaries, in these towns, for the purpose of public water supplies to the exclusion of all other municipalities.

Public Water Supply

UNH/Town of Durham



- The only active direct withdrawal from the designated reach.
- Water from Lamprey supplements water from Oyster River and pumping from Lee Well.
- For period 00-05 adjusted daily use from the Lamprey ranged from 10.3 to 492 thousand gpd (0.02 to 0.76 cfs).

Public Water Supply

UNH/Durham Section 401 Certificate Restrictions

- If summer flow between 45 & 21 cfs (0.25 & 0.11 cfs), 1.8 cfs (0.01 cfs) can be diverted.
- If summer flow between 21 & 13 cfs (0.11 & 0.07 cfs), 0.4 cfs (0.002 cfs) can be diverted.
- If summer flow less than 13 cfs (0.07 cfs) outflow = inflow to dam.
- Pool elevation cannot be drawn down more than 0.5 in. in 24 hours with a six inch maximum.

Public Water Supply

UNH/Town of Durham

- **Currently system only pumps water from Lamprey when flow at Packers Falls gage > 45 cfs because a monitoring system is not in place above dam.**
- **Investigating the development of new water supply well near Spruce Hole Bog.**
- **May also consider artificial recharge, divert during spring runoff and recharge aquifer.**

Public Water Supply

Newmarket Water Works

- **Currently obtains water supply from Bennett and Sewall Wells in Newmarket Plain Aquifer.**
- **Formerly diverted water from Folletts Brook, the Piscassic River and the Lamprey River, but abandoned due to water treatment issues.**
- **Recently received Groundwater Discharge Permit for artificial recharge of Newmarket Plain aquifer.**

Public Water Supply

Newmarket Water Works

- **Proposed source for recharge water is a diversion from the Lamprey River. Estimated withdrawal of 500,000 gallons per day (0.77cfs or 0.004 cfs).**
- **Intake may be placed in Lee in the designated segment or in Macallen Dam impoundment downstream of designated segment.**

Public Water Supply

- **No specific water supply PISF proposed.**
- **Water use by Newmarket Water Works and Durham/UNH to be evaluated during development of Water Management Plan.**
- **Conservation and Water Use Plans to be developed for each system as part of WMP.**
- **Goal is to minimize impact of water supply use on instream protected entities.**

Assessment of PISFs

UNH developed representative hydrographs for:

- Last five years (2003 – 2007)**
- Wet three years (2005 – 2007)**
- Average three years (1990 – 1992)**
- Dry three years (1964 – 1966)**

Proposed PISFs evaluated under these flow scenarios to estimate their impact and their range of influence.

Recreation PISF $Q \geq 275$ cfs

Representative Hydrograph		
	Days	%
Last five years	549	30.1
Wet three years	510	46.5
Average three years	407	37.1
Dry three years	235	21.4

Number of days in the hydrologic record flow meets the PISF and the per cent of time in the representative hydrograph.

Wood Turtle - Summer PISF

June 1 to October 15 $Q < 500$ cfs

Representative Hydrograph		
	Days	%
Last five years	670	97.8
Wet three years	374	91.0
Average three years	394	95.9
Dry three years	411	100.0

Number of days in the hydrologic record and bioperiod that the flow meets the PISF and the per cent of time in the representative hydrograph.

Bioperiod Approximate dates	Rearing & Growth July 5 - Oct. 6 (94 days)	Salmon Spawning Oct. 7 - Dec. 8 (63 days)	Overwintering Dec 9 - Feb. 28 (82 days)
Proposed PISFs	Recommended flows Common shiner	Recommended flows Atlantic Salmon	Recommended flows Flow
Watershed area (mi ²)	183	183	183
Location	USGS Gage	USGS Gage	USGS Gage
Common flow (cfs)	110	90	239
Common flow (cfsm)	0.60	0.49	1.31
Allowable duration under (days)	46	17	20
Catastrophic duration (days)	81	55	57
Critical flow (cfs)	22	40	110
Critical flow (cfsm)	0.12	0.22	0.60
Allowable duration under (days)	15	11	10
Catastrophic duration (days)	32	33	37
Rare flow (cfs)	16	20	73.6
Rare flow (cfsm)	0.09	0.11	0.40
Allowable duration under (days)	6	6	7
Catastrophic duration (days)	28	11	30

Bioperiod Approximate dates	Rearing & Growth July 5 - Oct. 6 (94 days)	Salmon Spawning Oct. 7 - Dec. 8 (63 days)	Overwintering Dec 9 - Feb. 28 (82 days)
Three-year average flow (1990 to 1992)	Recommended flows Common shiner	Recommended flows Atlantic Salmon	Recommended flows Flow
Common Flow in cfs	110	90	238
Times not met, <PISF, and (%)	204 (72)	8 (4.2)	91 (37)
Allowable duration under in days*	46 (1)	17 (0)	20 (1)
Catastrophic duration in days*	81 (1)	55 (0)	57 (0)
Critical flow in cfs	22	40	109.8
Times not met, <PISF and (%)	105 (37)	3 (1.6)	13 (5.3)
Allowable duration under in days*	15 (2)	11 (0)	10 (0)
Catastrophic duration in days*	32 (1)	33 (0)	37 (0)
Rare flow in cfs	16	20	73.2
Times not met, <PISF, and (%)	70 (25)	0 (0)	0 (0)
Allowable duration under in days*	6 (2)	6 (0)	7 (0)
Catastrophic duration in days*	28 (1)	11 (0)	30 (0)

Note: Allowable and catastrophic durations in days, and the number of years that duration was exceeded in ().

Bioperiod Approximate dates	Rearing & Growth July 5 - Oct. 6 (94 days)	Salmon Spawning Oct. 7 - Dec. 8 (63 days)	Overwintering Dec 9 - Feb. 28 (82 days)
Three-year low flow (1964 to 1966)	Recommended flows Common shiner	Recommended flows Atlantic Salmon	Recommended flows Flow
Common Flow in cfs	110	90	238
Times not met, <PISF, and (%)	261 (93)	128 (68)	180 (73)
Allowable duration under in days*	46 (3)	17 (3)	20 (3)
Catastrophic duration in days*	81 (1)	55 (2)	57 (1)
Critical flow in cfs	22	40	109.8
Times not met, <PISF and (%)	203 (72)	61 (32)	111 (45)
Allowable duration under in days*	15 (3)	11 (3)	10 (2)
Catastrophic duration in days*	32 (3)	33 (0)	37 (1)
Rare flow (cfs)	16	20	73.2
Times not met, <PISF, and (%)	167 (59)	15 (7.9)	58 (24)
Allowable duration under in days*	6 (3)	6 (1)	7 (2)
Catastrophic duration in days*	28 (2)	11 (1)	30 (0)

Note: Allowable and catastrophic durations in days, and the number of years that duration was exceeded in ().

Wiswall Dam and Durham/UNH Water Supply

45 cfs > Q > 21 cfs can withdraw 1.8 cfs

21 cfs > Q > 13 cfs can withdraw 0.4 cfs

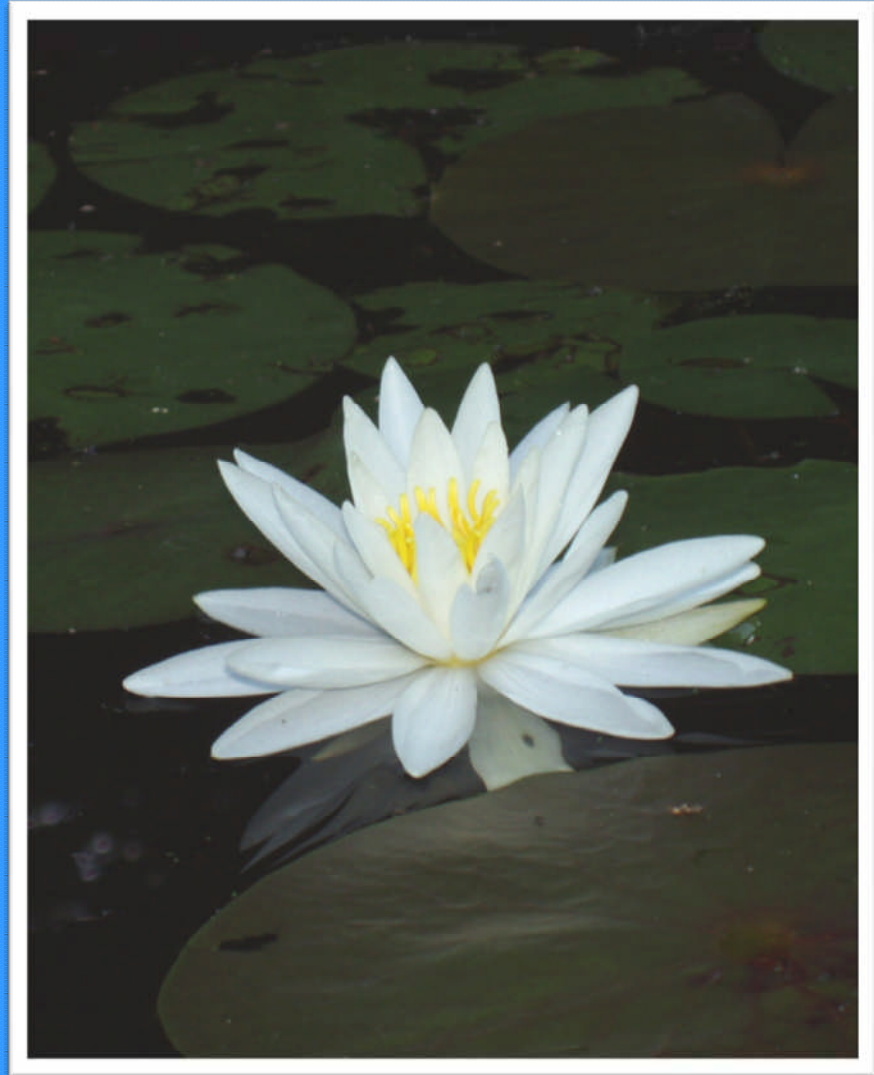
Q < 13 cfs no withdrawal (only from storage)

Representative Hydrograph	45-21 cfs		21-13 cfs		<13 cfs	
	Days	%	Days	%	Days	%
Last five years	150	8.2	99	5.4	158	8.7
Wet three years	86	7.8	64	5.8	37	3.4
Average three years	73	6.7	52	4.7	53	4.8
Dry three years	149	13.6	82	7.5	146	13.3

Number of days that streamflow falls within 401 Certificate withdrawal limit and the per cent of time in the representative period.

Final Recommendations

1. PISF for fish controlling flows.
2. Flow no less than 4 cfs (0.6% POR).
3. Additional conditions for RTE, plant communities and wildlife habitat.
4. PISFs maintained by implementation of Water Management Plan.



Final Recommendations

Additional Conditions:

Winter Survival and Development - December 1 through April 30

- >130 cfs seasonal mean – wood turtle
- >500 cfs for 1 week or more – herbaceous low riverbank, mannagrass, hempweed
- <1,500 cfs daily mean in April – vernal floodplain pool, Blanding's turtle

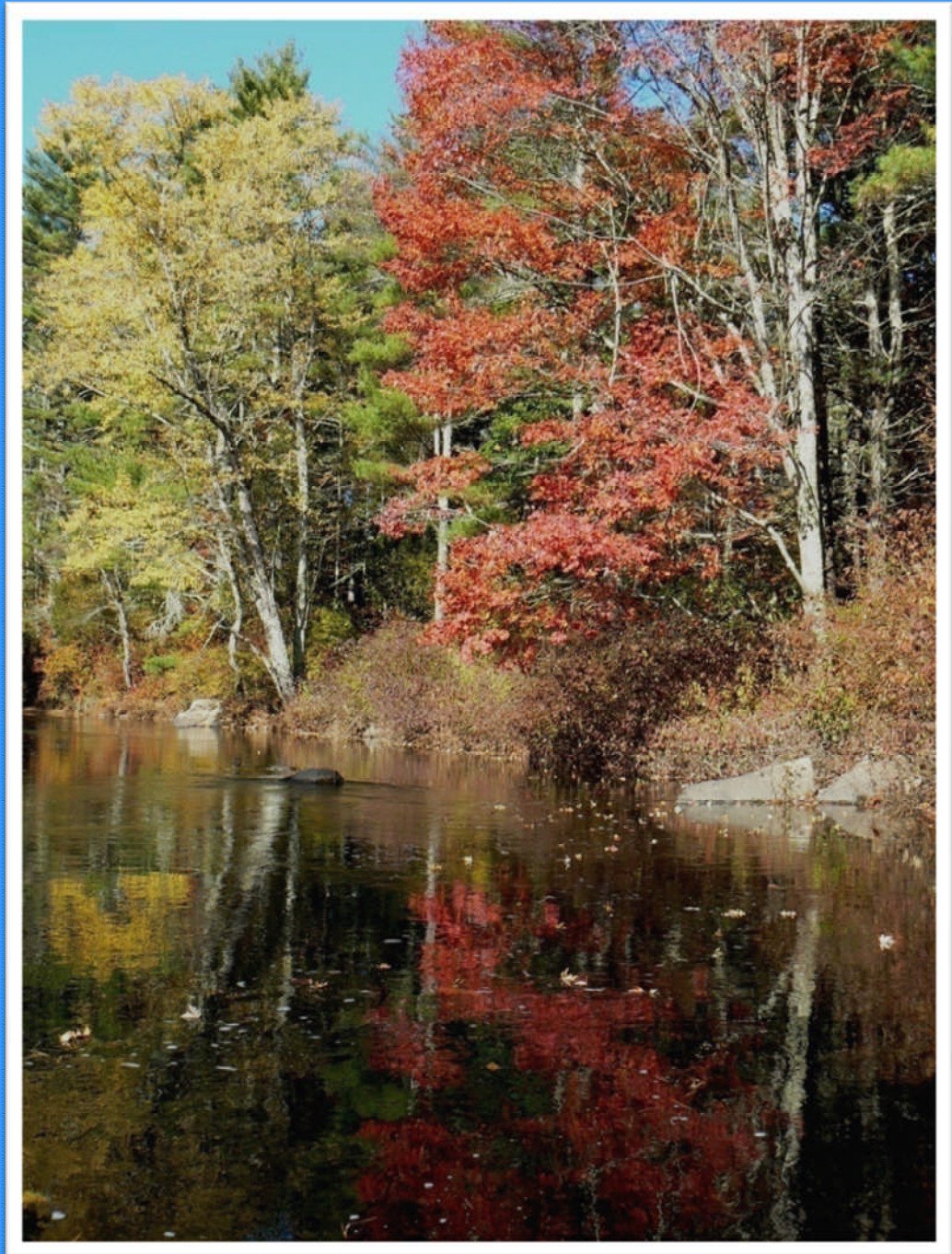
Spring Spawning May 1 through June 30

- >100 cfs seasonal mean – riverweed, knotty pondweed
- <500 cfs daily mean in June (wood turtle)
- <1,500 cfs daily mean in May - Blanding's turtle, floodplain vernal pools

Summer Survival and Development – July 1 through Sept 30

- <500 cfs daily mean in July – wood turtle
- \leq 60 cfs daily mean in August/Sept – Herbaceous low riverbank
- <100 cfs seasonal mean – August /Sept – riverweed, knotty pondweed

**Comments or
Questions?**



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